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THE

BOTANICAL GAZETTE

JULY 1911

THE VEGETATION OF CRANBERRY ISLAND (OHIO) AND ITS RELATIONS TO THE SUBSTRATUM, TEMPERATURE, AND EVAPORATION.[1] I

ALFRED DACHNOWSKI

(WITH SEVEN FIGURES)

The object of the present paper is to give, as briefly as is consistent with a limited presentation, the major conditions of some of the factors which have been found limiting the activity of plants in bogs.

The striking discontinuity of bogs in distribution, the absence of genetic relationship between bog plants and the surrounding flora of states in the latitude of Ohio, and the floristic agreement of these plants with the vegetation of the distant north has invited the attention of many students of ecology.

As early as 1872 a solution of this interesting problem had been formulated by GRAY (**14**) in his glacial relict theory. A similar explanation has been advanced by numerous recent writers, and the broader relations which involve comparative studies have been well established (**31**). However, the reciprocal relations of these plants and their habitat, the demands which the plants make on their environment, the means which they employ, and the functional rôle which the particular species perform; in short, an investigation of factors by which the present associations are determined and which would account for the existence and the peculiarities, structural and functional, of these "boreal" plants

[1] Contribution from the Botanical Laboratory, Ohio State University, no. 61.

on the basis of their relation to the present ecological conditions of their habitat, this has been a far more difficult matter and has not met with unanimity of opinion. A knowledge of the flora of a region and the floristic status of successive periods of time is indispensable, if for no other reason than to indicate the various conditions frequented by species or groups of plants. But the statistical method must be supplemented by an adequate study of experimental tests. The varying activity of plants as individuals and communities is of greatest importance scientifically and must be determined in the field under measured conditions.

Various theories have been put forward from time to time as to the environmental relations of plants in bogs, but none of them can be said to have brought nearer a solution of this phase of the problem. The historical aspect of the question need not be dealt with here in detail. The more important theories are those advanced by the following writers: KIHLMAN (**19**) regards low temperature and strong drying winds as the prominent factors in high northern latitudes; SCHIMPER (**29**) emphasizes humus acids in the soil, abundance of soluble salts and alkalies, and regards bog habitats as being "physiologically dry"; LIVINGSTON (**22**) suggests the presence of chemical substances not in direct relation to acidity of the soil as acting on the vegetation; WARMING (**32**) is inclined to look upon the presence of free humus acids as the weightiest cause; FRÜH and SCHRÖTER (**13**) correlate the conditions with low temperature and lack of aeration in the soil; while SCHWENDENER (**30**) and CLEMENTS (**5**) hold that the structural peculiarities are not at all related to present habitat conditions but are primitive peculiarities, which now remain unaltered but were originally developed under different xerophytic conditions. Another explanation, that of the toxicity of the habitat, and its consequent physiological aridity and selective operation upon forms striving for occupancy, has been offered by the writer of this paper. This view has come from a more detailed investigation of the physical and chemical characteristics of bog soils and their physiological property (**7, 8**). It emphasizes the active participation of specific microorganisms and fungi, a view which correlates also very well with the unproductiveness of differ-

ent peat soils under cultivation examined by the writer, and lays stress not alone upon structural characteristics in plants but also upon limiting habitat conditions as conducive to the development of place-functions. That various factors enter into the problem, and possibly many others not yet discovered have a part directly or indirectly, is clearly recognized.

Further field work on the bog plant societies has been carried out especially with a view to test the reference made by several writers to the part played by low substratum temperature and by the evaporating power of the air. In addition, studies on the physical, chemical, and biological problems of the substratum were continued.

It is obvious that the physical conditions, whether temperature or evaporation, if sufficiently great in their differences, must have an important bearing on the question of distribution and of xerophytism in bog plants. The larger part of the body of bog plants is imbedded in the peat at various depths. The various functions take place only within lower and upper critical conditioning factors. For instance, the germination of seeds, the activity of roots and rhizomes, the permeability of protoplasmic membranes, the rate of absorption and chemical action during growth in underground organs, must be greatly affected by the actual extreme temperatures encountered, as well as by the rapidity with which changes in temperature occur. The diurnal and seasonal temperature changes in the peat soil, and the differences in temperature between the aerial and underground portions of plants cannot fail to be of equally great importance in the physical and chemical processes, in the activity of the soil organisms on those biological changes which modify soil productiveness, and in the reciprocal physiological influences upon which absorption, transpiration, and transport of solutions from one part of the plant to another depend. The task of securing a coordination between these functions must be indeed a complicated one, varying greatly in different species according to their capacity of endurance. It is therefore clear that conditions as regards efficient temperature determine greatly the physiognomy of the individual plant and of the whole of the vegetation in habit of growth and distribution. But the rôle

which temperature plays quantitatively and qualitatively in the distribution of bog plant societies is in the main not known. So far as the writer is aware, no quantitative measurements between temperature as a probable causative or limiting factor and the resulting function and form in bog plants has been previously conducted, such as would afford any definite record of the actual physical conditions obtaining at different substratum levels in a bog vegetation. What has been said for temperature holds true also for evaporation. The influence of this and other factors is among the pressing problems of physiological ecology. From this point of view the data presented below have been collected in the field during the past three years.

The physical factors which modify and more or less control the community of plants on Cranberry Island have been formulated for the most part quantitatively. Yet it must be frankly admitted that, at the present time, interpretation of the data thus far gained is still only in part possible. Though the data have been gained laboriously through many months, and to the writer seem convincing, to attempt to correlate these accurately may be ill-advised. Only by the multiplication of such data will it be possible to express the results with quantitative exactness. The very necessity, however, of recording and accumulating an extended series of comparative observations is the justification of publishing now the data at hand. The conclusions here expressed, therefore, are still tentative, and true for the local investigation only.

Frequently the writer's students have assisted in this work, and acknowledgment is due to Messrs. L. W. SHERMAN, E. WRIGHT, E. LINN, L. KING, and M. G. DICKEY for efficient aid. The warmest thanks of the writer are expressed here also to Professor J. R. CHAMBERLAIN, who surveyed the island, to Professors N. W. LORD, W. E. HENDERSON, and C. W. FOULK for cooperation in the chemical analyses, and to Miss F. DETMERS for identification of plants and the care with which the floristic study has been generally furthered. The expense of the field work has been covered in large part by a special grant from the Emerson McMillin Research fund.

The habitat

The field work which forms the basis of the present paper was carried on at Buckeye Lake, Ohio. The geological record of the region is for interest second to few places in Ohio. The strata furnish an almost unbroken narrative from the Silurian up to the Tertiary. It is a rare thing to find peat bogs in Ohio south of latitude 40°, and this circumstance makes the locality as the southernmost limit of existing peat formations still more interest-

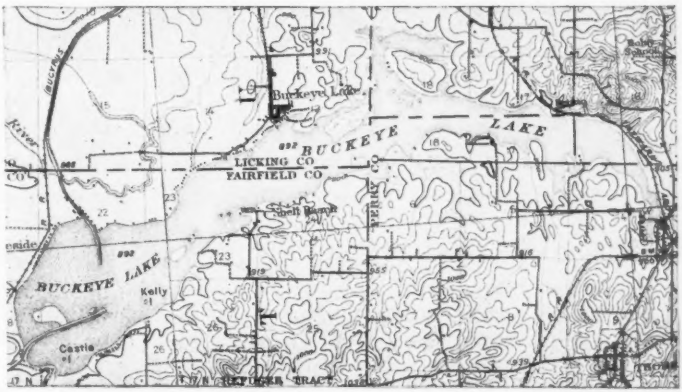

FIG. 1.—Topographic map of Buckeye Lake and vicinity; U.S. Geological Survey, 1907; contour interval 20 feet (6 m.); scale, 1 inch = 1 mile (2.5 cm. = 1.6 km.).

ing. And to complete the panorama of the great past, the remains of the moundbuilders found near Newark, Jacksonville, and other places in the vicinity continue the record down to the historical period.

Buckeye Lake is situated in Licking, Fairfield, and Perry counties, about 26 miles (41 km.) east of Columbus, and is at an elevation of 150 feet (45 m.) above that of the University campus. The area and location are shown on the Thornville sheet of the U.S. Geological Survey (fig. 1). The lake, like many others, is one characteristic of the highlands of watersheds throughout Ohio and adjoining states. The heath bogs in Wyandot County, the extensive bogs in Huron County, possibly among the largest

peat deposits in the United States, the Pymatuning tamarack swamp in Ashtabula County are similar members of this interesting chain of water basins marking the less perfectly drained summit of divides. The depressions on such summits receive water which creates no surplus and hence has almost no eroding powers. Buckeye Lake is now an extensive body of water, about 10 miles (16 km.) long, and one mile (1.6 km.) wide, but was originally a pond in the glacial drift, containing approximately 595 acres (238 hectars). Its chief water supply today is the south branch of the Licking River.

The lake basin lies near the southeastern margin of the terminal moraine. The main western member of the morainic system is about 3–5 miles (5–8 km.) in width. It presents marked differences in topography, the closely aggregated knolls and ridges rendering the belt readily distinguishable from the bordering plain. The knolls are generally conical in form with gentle slopes, ordinarily about 25–100 feet (7.5–30 m.) in height. These knolls were apparently formed at the time the gravel plain was being built up. They are thought to indicate that the head of the gravel plain was built up as a submarginal deposit to about its present height before the ice sheet had withdrawn from over it (**20**). The lake basin under discussion resulted from the comparatively slow retreat of glaciers and the consequent greater deposition of glacial material about the edge of a body of ice in an old glacial drainage channel. The "kettle" is characterized by comparatively steep slopes. Up to 1832 the lake was surrounded by about 3000 acres (1200 hectars) of swamp land covered with large trees (fig. 2). The report of Captain CHITTENDEN, as quoted by GRAY (**15**), gives the area of the lake at that time as 3300 acres (1320 hectars), which agrees very closely with its area as determined by later surveys. The present lake was formed in 1828 and completed in 1832, to serve as a reservoir for the Ohio and Erie Canal. The surface water was raised about 8 feet (2.4 m.) by forming a dike around the west end and a part of the north side of the swamp. It was hoped to supply the Ohio Canal with water from Newark to Little Walnut Creek, south of Lockville, a distance of 31 miles (5 km.), and the deficiency between Little

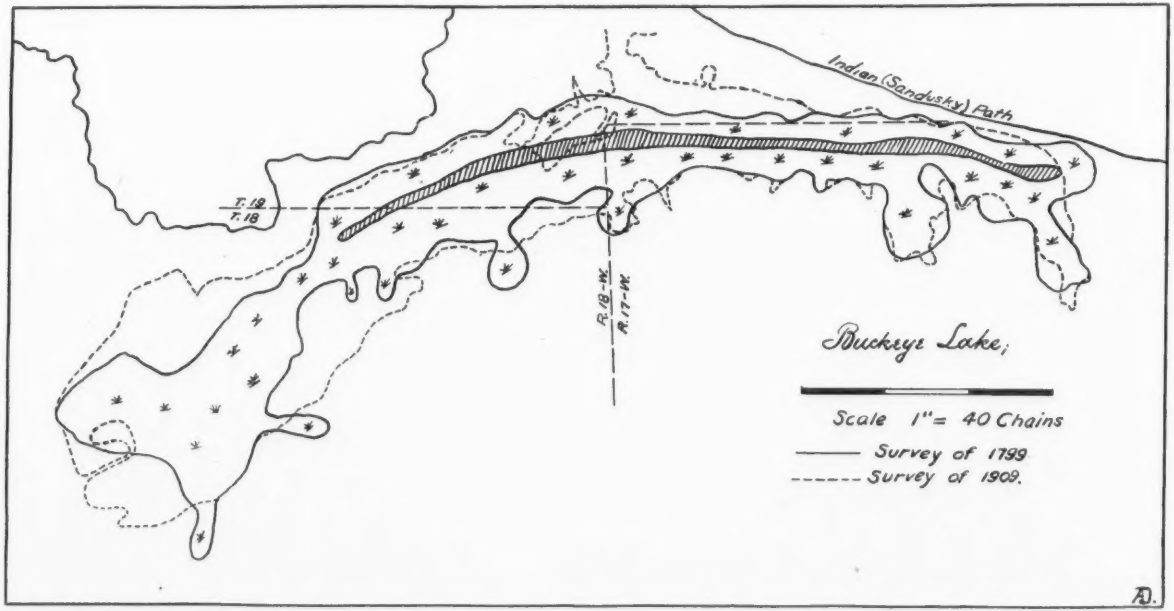

FIG. 2.—Buckeye Lake in 1799 and 1909; from tracings of the survey maps in the State Auditor's office at Columbus, Ohio.

Walnut Creek and Lockbourne. The reservoir soon proved inadequate for the canal, and in 1834 about 700 acres (280 hectars) were added, forming its present area. Its watershed embraces about 90 square miles (2331 hectars), which cannot be greatly enlarged. The lake then known as Licking Reservoir has, however, never stored a sufficient water supply and is not used for transportation purposes now. A large number of trees then standing soon died and fell into the water, where they remained beneath the surface. The majority of the trees were gradually cut away with

FIG. 3.—Cranberry Island; the view is from a hill northwest of the island near Buckeye Lake Station; to the left the woodlot; in the distance members of the terminal moraine; photographed August 1910.

their stumps exposed during low water. Only recently (the winter of 1908) the greater part of these stumps has been removed.

Near the northern bank of the lake, about one-half mile (0.16 km.) southeast of Buckeye Lake station, is the bog island, approximately one-tenth the dimensions of the lake (fig. 3). In position it is more or less sheltered by hills and a woodlot. The peat mass rises and falls with the changing water level of the lake, and supports a vigorous growth of trees, low bushes, sphagnum mosses, and cranberrries. Borings were made at various points on the island with a sampling tool devised by DAVIS (**2**), to determine the depth and the character of the peat. About 50 soundings were made, which indicate an average depth of peat of 30–35 feet (9–10 m.) along the southern shore of the bog island, and 11 feet

(3 m.) of peat along its northern shore. Borings made to the depth of 40 feet (12 m.) at the southernmost points of the island, and in the lake south of it, failed to reach bottom. The following table (I) gives some of the borings and related observations. The borings were made at a time when, for purpose of repair, the water surface of the lake was lowered 5 feet (1.5 m.) below the normal niveau.

TABLE I

ANALYSIS OF PEAT SPECIMENS FROM CRANBERRY ISLAND, BUCKEYE LAKE, OHIO

Analysis nos.	Station	Depth ft.	Depth meters	Description of peat samples
5.....	Central zone; sphagnum-cranberry	5	1.5	Brown, fibrous peat; mostly cranberry, sphagnum, and sedges.
7.....		14	4.2	Brown, non-fibrous, plastic peat with diatoms and shell marl.
8.....		25	7.5	Dark brown, well decayed, finely granular peat; algae (?) and filling from marginal borders.
9.....		40	12.0	Nearly black, non-fibrous, clayey peat.
11.....	Maple-alder zone	6	1.8	Dark brown, slightly fibered peat, coarser fibered below.
12.....		10	3.0	Brown and fibrous peat.
14.....		18	5.4	Dark brown, well decayed, finely granular peat with shell marl.
21.....		31	9.3	Fine sand with clay underneath.
22.....	Northeast station	5	1.5	Brown, fibrous peat; mostly cranberry, sphagnum, and sedges.
26.....		18	5.4	Granular peat; very sandy above, marly beneath.
27.....		28	8.4	Sandy marl; blue clay beneath.
28.....	Southeast station	5	1.5	Brown, coarse fibrous peat.
29.....		10	3.0	Dark brown, slightly fibrous; a lighter colored coarse fibrous peat underneath.
30.....		20	6.0	Brown, fibrous peat containing roots and rhizome fragments.
31.....		40	12.0	Black, plastic, non-fibrous peat; bottom not reached.
32.....	Southwest station	5	1.5	Light brown, coarse fibrous peat.
36.....		20	6.0	Plastic, fine fibered, dark brown peat containing shell marl.
38.....		40	12.0	Black, plastic, non-fibrous peat; bottom not reached.
40.....	Northwest station	5	1.5	Light brown, fibrous peat, composed of sphagnum and other bog plants.
42.....		20	6.0	Fine fibered, dark brown peat.
45.....		28	8.4	Sandy gravel underlain by blue clay.
48.....	Lake station	6	1.8	Dark brown, slightly fibrous peat.
49.....		40	12.0	Black, plastic, non-fibrous peat; bottom not reached.

It will be seen that the accumulation of vegetable matter has been sufficient to cause the lake basin to be filled with a layer of peat of considerable depth. The deeper strata have been reduced by humification, largely to the form of a black humus, a semi-liquid muck. The fineness of grain and the peculiarly soft consistency of it suggest that it is in part made up of the remains of algae, and in part a filling from the border of the lake, spread over the bottom. The upper strata are lighter in color, and very fibrous, loosely felted in structure, and have a matted appearance. As the island is sounded through from top to bottom, the samples brought up show a progressive change in color from light to darker shades, and in texture from coarse and loose to fine and more compact peat always saturated with water. In some places this sequence is repeated, that is, below the peat muck occurs a second fibrous brown layer followed by muck or clay. The escape of gases is very noticeable during the test borings, and also the staining of the brass peat sampler to a bluish-purple bronze, indicating the presence of a gas like hydrogen bisulphide. Only a small deposit of shell marl has thus far been found underlying the peat substratum in places. The Characeae and Cyanophyceae concerned with this process (10) are not abundant enough to be considered as agents in the aggradation of the basin. The lake bottom is of clay and in places somewhat sandy. The thickness of the deposit of peat in this morainal depression indicates, therefore, that the vegetation must have obtained an early foothold.

The chemical analysis of the substratum

The drainage of the bog island is merely that due to seepage through the porous peat. Ordinarily very little water passes either into or out of the bog island, except at such times when the water level of the lake fluctuates with extremes in precipitation or from interference in drainage. Even then the seepage is not rapid. The amount of salts dissolved in the lake water which is retained by absorption in the humus soils along the margin of the bog island is relatively small. The analyses show a total mineral content of 4 and 9 parts per hundred for the central and marginal zones respectively. Average samples of the air-dried peat taken

at a depth of one foot (30 cm.) from the surface layer give the following chemical composition (table II). For purposes of comparison analyses have been added of peat soils from a tamarack bog near Edgerton, Ohio (station VII), from a bog near Orrville, Ohio, now under cultivation in celery, onions, etc. (station VIII), and from a peat bog under cultivation, the soil of which is reported as unproductive (station IX).

TABLE II

CHEMICAL ANALYSES OF PEAT SAMPLES

Constituents	Sphagnum-cranberry zone	Maple-alder zone	Tamarack zone	Cultivated peat	Diseased peat
Volatile matter	60.90	68.91	60.50	52.47	52.56
Fixed carbon	22.19	19.60	26.84	23.98	19.35
Ash	7.68	3.56	3.30	14.70	19.42
Sulphur	0.12	0.00	0.20	0.39	2.21
Nitrogen (equivalent to ammonia)	0.80	2.55	1.51	2.58	2.38
Potash (K_2O)	0.12	0.12	0.15	0.31	0.64
Phosphoric acid (P_2O_5)	0.03	0.03	0.29	0.34	0.37
Insoluble	0.00	0.00	0.15	0.07	0.15
Available	0.03	0.03	0.14	0.27	0.22

It appears, therefore, that where peat varies from a highly fibrous condition, light brown in color, as in the sphagnum-cranberry zone, to a structureless condition, i.e., well decomposed, only slightly fibrous, and dark brown in color, as in the maple-alder zone, not only the physical constitution but also the chemical composition is highly variable. The determinations, which were made in the same way as fertilizer analyses, show conclusively that from the standpoint of available plant food constituents, the peat of the maple-alder zone is superior to that of the central sphagnum-cranberry zone. The analyses of peat ashes indicate only a small fraction of a per cent of potash and of phosphoric acid, but a fairly large amount of the valuable nitrogen ingredient. Preliminary work indicates also that the relative availability of the peat nitrogen seems at the most 8 to 12 per cent; but that this relative availability of peat nitrogen is considerably increased when the peat is composted with the bacterial life from stable manure, the peat from the central sphagnum-cranberry zone dis-

integrating, however, less readily than that from the maple-alder zone.

The reducing action of peat soil

It is a well known fact that fresh samples of bog soil upon exposure to the air extract oxygen from the air with great rapidity. Soil-sampling tests show that this power is strong in the cranberry-sphagnum peat, reaches a maximum in areas where the peat substratum is compact and less coarsely fibrous, and decreases as the border zone along the margin of the lake is reached. Judged by the quickness with which the soil becomes colored, and the intensity of the color, reducing processes increase on Cranberry Island from any marginal point to the central zone, and decrease as the opposite shore is approached. Reduction action becomes greater with the depth of the deposit.

The reducing power of the soils is shown clearly by the addition of a starch iodide solution. The observable action is variable, as already mentioned; the blue color disappears rapidly in soils from the cranberry-sphagnum area; the solution is greatly lightened with soils nearer the margin of the lake; no action is detected with soils along the margin. Various dyes such as lacmus and methylene blue and other coal tar colors decolorize similarly. Possibly the absence of sulphur in the analysis of maple-alder peat (table II) is due to the complete conversion of sulphur to hydrogen sulphide. This gas is the product of a reduction and has been detected by means of lead acetate paper.

Whether the reduction power in peat soils is produced by microorganisms, is due to enzymes, or caused by external chemical or bacterial metabolic products, these tests fail to show. Nothing absolutely certain is known regarding the composition and the nature of reducing substances. They have not at present been very fully studied by ecological workers. Apart from their destruction by aeration, tillage, and heat, and their adsorption by insoluble substances such as quartz, kaolin, carborundum, lamp black, and others, uncertainty exists as to whether the reducing bodies in bogs are unsaturated compounds comparable in properties to unsaturated fatty acids, to substances which possess the characteristics of certain organic reducing ferments, or to

residual by-products of an incomplete disintegration of peat. They unquestionably reduce oxygen-containing compounds in contact with them; their action is most marked where micro-organisms play a part in decomposing organic matter; the amount reaches, it seems, a maximum in early autumn. It should be stated further that toxicity and the reducing action of peat soil and that of the decomposing organic matter which retards oxidation in the soil are not necessarily the same phenomena. An increase in the amount of oxygen does not always decrease toxicity or the reducing power of the soil, and hence the amount of oxygen absorbed cannot be taken as the measure of the total action of these conditions.

Reduction processes are predominant in the early stages of peat formation, but are less manifest as the concomitant plant societies are succeeded by others, and especially when deciduous forests prevail. The same factors which decrease the toxicity of the habitat and the accompanying reducing processes favor an increase in the rate of oxidation and influence thus the character and nature of the succession. The greater oxidation, therefore, in the known productive peat soils would seem to be due to the activity of a different set of microorganisms, which by enzymotic action or otherwise hasten the formation of compounds of an assimilable nature. The excessive oxygen avidity of peat soils in the early formation stages must undoubtedly be injurious to plants, unless the plants, indigenous or invaders, are likewise able to exhibit oxidizing or reducing powers. The reducing processes in a soil very likely activate oxidative powers in plants. The various reactions of fungi, micorhiza, alder tubercules, bacteria, and the roots of higher plants growing in peat and humus soils should on that account be made the subject of considerably greater and more detailed study. The consideration of the relation between plant societies, relative physiological aridity, and micro-organisms, with their reductive and oxidation processes in soil has scarcely passed beyond the theoretic field of speculation. And yet it is this relation which makes soil problems especially interesting and in need of experimental work of considerable scope (**28**).

The bog water is relatively clear, the suspended particles imparting to it a slight tinge of olive green to brown. The analysis of samples of bog water and lake water give the following results (table III).

TABLE III

CHEMICAL ANALYSIS OF BOG WATER AND LAKE WATER FROM CRANBERRY ISLAND

Constituents in parts per million (May 30, 1910)	Bog water, central zone (cranberry-sphagnum)	Lake water
Nitrogen as albuminoid ammonia	10.34	4.50
Nitrogen as free ammonia	5.19	2.95
Nitrogen as nitrites	0.0005	0.0000
Nitrogen as nitrates	0.20	0.10
Chlorine	0.30	1.00
Required oxygen	71.80	3.70
Alkalinity (as $CaCO_3$)	30.00	75.00
Incrustants (as $CaCO_3$)	74.00	76.00
Total solids	140.00	200.00
Loss on ignition	100.00	4.00

Examining these results, shown in table III, we find that the lake water contains organic matter in a state of advanced decomposition. This is indicated by the relatively high free ammonia, and the small amount of oxygen consumed. The reverse holds true for bog water from the sphagnum-cranberry zone. In other points lake water agrees well with bog water. The osmotic pressure and the acidity have been found to be the same for both stations. As compared with the freezing point of pure distilled water, the average lowering in the various determinations is 0°.007 and 0°.009 for the central station and the maple-alder and lake station respectively. Acidity varies from less than 0.00075 to 0.0038 normal acid when titrated with a $n/0.05$ NaOH solution. The soil is alkaline at depths near the marly subsoil. The stress laid by various authors upon the relation of these two factors to plant societies in bogs, in so far at least as this region is concerned, will not hold. They are not factors in the selection or distribution of species for bog habitats.

Physiological properties of bog water

The physical and chemical sides are found unsatisfactory to explain the functional variations and the pathological changes

in structure which agricultural plants undergo when growing in peat and bog water. Elsewhere it was shown by means of transpiration data of cultivated plants, and with a biometric study on the annual wood-increment in the red maple found on the island and in woodlots near the shore, that (1) a difference exists between different species in their power of resistance to the toxic action of the substratum; (2) the contrasts in the relative growth of plants vary with the substrata of the several bog plant formations; (3) the toxic principles whether enzymes or other bodies are not found in bog water when attempts are made to extract them with insoluble adsorbing bodies; they do not pass readily through filters and only slightly through filter paper; (4) different physiological phases result from the progressive addition of an adsorbing substance; (5) agricultural soils used as filters decrease considerably the normal physiological activity of plants growing in them; (6) the reduced absorptive capacity of the plants is not a consequence of the absence of root hairs, or of a smaller absorbing surface.

The bacterial flora of the peat substratum

Present writers seem to hold the view that among the simplest of fungi, the Schizomycetes, few are present in peat bogs, and that only a small number of species, included in perhaps only one family, are at all injurious to higher plants. Examination has shown that peat soils contain unsuspected groups of bacteria, which in number and efficiency vary during the seasons and with the several plant zones on the island. As a means of differentiation between the bacterial flora of the plant formations, studies were made on the action of the bacteria in 0.5 cc. bog water upon various culture media in fermentation tubes. Soil water solutions were collected in sterilized glass-stoppered bottles from each of the following stations: station I, lake water; station II, marginal zone (*Decodon-Typha-Hibiscus*); station III, cranberry-sphagnum zone, 1–3 feet; station IV, same, 3–5 feet below surface vegetation; station V, maple-alder zone, 1–3 feet; station VI, same, 3–5 feet below surface vegetation; station VII, tamarack soil from Edgerton, Ohio; station VIII, peat soil under cultiva-

tion from Orrville, Ohio; station IX, peat soil under cultivation, reported as unproductive and "sterile," from Lodi, Ohio; station X, humus soil from the university woodlot (beech-oak-maple-elm). The culture media employed for this work were a 1 per cent starch peptone water solution; 1 per cent solutions of cane sugar, dextrose, and lactose in beef broth; plain bouillon; plain and litmus milk; 0.2 per cent nitrate peptone water; Dunham's peptone solution for the indol test; nutrient gelatin and agar. Only the generally well known determinations, as of the breaking up of carbon and nitrogen compounds and the proportion of the various gases evolved, have been made. The chemical analysis of the soil samples of stations I to IX is given in tables II and III.

The culture studies gave the following characteristic results after an incubation period of 5 days at 38° C. The action of the bacteria on starch shows in several stations the production of an inverting ferment by the cultures. The starch is changed into a sugar which reacts with the Fehling's test. In stations III and IX there is no action; in stations II and X the conversion is carried on a little way and then stops, there being always a red or purple reaction with iodine; in station I the starch conversion is almost complete; while in stations IV, V, VI, and VII certain putrid by-products inhibit in various degrees further conversion. Upon the addition of a few drops of potassium iodide, the blue color disappears rapidly in stations III, IV, and VI; the hydrated iodine is deposited as metallic iodine upon the walls of the test tube above the solution. Reduction action is less active in stations V, VII, and IX. No decolorization occurs in stations I, II and X. The accumulation of iodine is very strong in the test tube of station X and is very likely an indication of the presence of oxidizing ferments. With methylene blue the reduction action is the same in degree, respectively, in all cases running parallel with the iodine action.

In all stations, with the exception of station I, the action of the bacteria on saccharose shows both the conversion of the carbohydrate into glucose by the inverting ferment, and the production of gas and acid. The reaction is strongest in stations VIII and X; relatively small in stations V and IX; very little gas is evolved

in station II. The gas is largely hydrogen gas and CO_2; the latter, with the exception of stations V and VIII, is present usually in small quantities and was distinguished from other gases by its absorption in sodium hydroxide. Fermentation action is shown better on dextrose and lactose. There is little growth and gas formation in station I; no acid is produced in stations VII and IX; and very little hydrogen gas is formed in station VIII. In all cases the growth of the organisms produces a marked and varied pigmentation in the solutions.

In plain milk, rapid coagulation precedes further bacterial action in all cases except station IX, in which coagulation occurs very slowly. Milk is slowly peptonized anaerobically in stations IV, V, and VI; surface digestion takes place in stations III, VIII, IX, and X; it is rapid in stations I, III, and VI; and gas is produced in moderate quantities in all stations except station VIII. Litmus milk is coagulated in all stations; the medium gradually decolorizes and the cultures become acid in various degrees; the color does not return upon steaming the test tubes. With a majority, gas is produced in various amounts during digestion, except in station IX, in which the bacterial reaction is faint though strongly odorous.

On bouillon bacterial growth is slow; it is never very turbid or heavily clouded, and only in one case, station IX, gives a whitish precipitate.

The power of indol production is greatest with the organisms in stations III, V, and IX; the action is relatively small in stations II, IV, VI, and VII; and present to a feeble extent only in stations I, VIII, and X when tested with 0.02 per cent solution of potassium nitrite and sulphuric acid.

The ability to form nitrites from nitrates in nitrate broth is common to the organisms in all stations. The amount of nitrites formed is high in stations IV, VI, IX, and X, and very small in stations I, II, VII, and VIII. The power to reduce nitrates to nitrites is not present in the same degree as noted above for the reduction action in starch media. It is certain that the microorganisms are capable of reducing nitrates, but to some extent metabolic products, apparently, modify the action. The test

was made with equal parts of sulphanilic acid and napthylamine solution.

The presence of ammonia was tested with Nessler's reagent. The reaction is stronger in stations VII and X than in any other station. A faint test is obtained in station IX. Nitrogen gas is produced from nitrates in stations VII and VIII.[2]

Before summarizing the facts brought out in the culture studies, there is need of mentioning another matter. A knowledge of the morphology of the simple form of organisms does not suffice to differentiate the numberless more or less similar species. It is difficult and almost impossible to identify a distinct and constant type for each species, or recognize form-differences suitable for classification. Nor does it seem that culture methods have made possible systematic grouping, or the variety of tests needed for accurate and trustworthy comparisons. No necessity exists for doubting the value of cultural characters; it is merely maintained here that additional and new methods must be tried, and tests should be scrutinized from every standpoint. Though widely different in their behavior in culture media and in their relation to air, yet the pathogenic properties of the bacterial flora from the different plant formations and societies should be ascertained within the limits of their natural habitat, and should be determined also with reference especially to the degree of functional inhibition on higher plants. It is not until a study is made of the special reaction of bacterial transformation products in sterilized bog water upon the growth of agricultural plants that the lack of salient features between habitat relations and physico-chemical reactions in artificial media becomes noticeable. Considerable difficulty was experienced in the isolation of organisms with the conventional media. In the majority of cases very little growth was obtained on beef broth gelatin or agar. Gelatin and agar media made with peat and bog plant juices proved more satisfactory for isolation purposes. Moreover, bacteria of rapid growth and early appearance of colonies on the artificial media

[2] Since the observations herein recorded, the writer received through the courtesy of Professor HARSHBERGER a paper published by Dr. D. RIVAS on "Bacteria and other fungi in relation to the soil" (Univ. Penn. Publ. 3:243–274. 1910). It is cited here as bearing directly on the problem in hand.

caused less retardation on the growth and transpiration of wheat plants when inoculated into sterilized bog water than bacteria of slow growth. In some cases the isolated pure cultures made little headway on beef broth or peat agar media after a period of 3–5 months, but gave strong inhibition in the growth of wheat plants within 3 weeks after inoculation into sterilized bog water from their respective plant zones. It is reasonable to assume, therefore, that the lack of uniformity in results implies both obligative symbiosis and the need of a physiologically balanced culture medium. The fact that the organisms are obligate saprophytes, capable of growing only on substrata similar in composition to the character of the surface vegetation, is indicative of a close interdependence; their rapid growth in a medium in which cellulose and lignin compounds predominate suggests a specific cytohydrolytic action. Certain microorganisms in station III have been found to possess the ability to dissolve filter paper, but their isolation has not been successful.

It is needless here to repeat the physiological tests which were made with a number of isolated pure cultures inoculated in sterilized bog water. Transpiration figures of wheat plants growing in these solutions and various other data have been published in an earlier paper (*l.c.* 9) to show the active participation of the organisms in the formation of bog toxins, and their ability to inhibit during the processes of denitrification and dehydration the growth of plants alien to the habitat. With these suggestions in mind, the results on the bacterial reactions in culture media submitted above may now be summarized as follows:

Peat soils are very rich in bacteria inducing diastatic, inverting, proteolytic, cytohydrolytic, and reducing action.

The organisms vary in kind and number with the nature of the substratum.

The majority of the forms are found to thrive as saprophytes, digesting the débris in the upper layer of the peat substratum and aiding in a partial disintegration of the accumulating deposit. Many forms thriving as saprophytes among the indigenous flora give little aid in the elaboration of food materials to invading or introduced plants.

The organisms show a marked interdependence between themselves; one set of bacteria prepares a medium for another out of an unfavorable substratum, and this paves the way for others to continue the destruction. Signs are not lacking, however, of relative indifference and even antagonism among the organisms, resulting in products which retard and inhibit further bacterial growth and disintegration processes.

A certain proportion of bacteria in these soils has the special ability to produce substances, perhaps unassimilable, certainly injurious to all but indigenous plants. In a peat substratum the percentage of bacteria aiding in the production of deleterious substances such as reducing bodies, gases, indol, and other fermentation products varies with the season of the year, but especially with the advance of the vegetation toward the closed deciduous forest formation. These bodies constitute the unsanitary conditions in soils, the negative factor which limits the rate at which the splitting up of organic compounds into ammonia and other assimilable substances proceeds. They are the characteristic symptoms of a diseased, sterile soil. The greater oxidation in the productive peat soil is due to the activity of a different set of bacterial organisms. The rôle which microorganisms play in the soil points, therefore, to the fact that among other things a considerable relation exists between the processes of disintegration of organic material and the succession of plant formations in bogs and marshes, and in peat soil under cultivation.

Each plant formation has its own bacterial flora maintaining a physiologically balanced condition in the soil. The substratum of each plant formation is an ever varying medium, the seat of physical, chemical, and vital activities which directly and indirectly influence its relative fertility and the character of the surface flora. Varying with the power of multiplication and metabolic activity is the quantity of the products of decomposition constituting a toxic, physiologically arid habitat at one phase, and an available supply of nutrients to plants at another stage of the process. Acidity, toxicity, and reduction action represent merely a stage in the decomposition of organic matter. In the natural successions which ensue, each plant association augments the

efficiency of the soil as a habitat. The soil processes involved are an efficient natural process for the maintenance of relative productivity. Differences in the mineral components are trifling compared with the biological processes.

The sum total of the reactions in any stage of the process exercises a physiologically selective function upon invading plants, furthering the growth of such plants whose roots are not merely absorbing organs, and excluding and eliminating all others in which the power to make extracellular changes in the soil is inefficient.

The significance of the data calls, however, for still further experimentation to be of sufficient evidence to assume a specific metabolism in bog plants, or to disclose the chemical nature of bog toxins.

Origin of the habitat

Initially the bog island was formed as are all bogs occurring in glacial moraines, or in depressions which form frequently in the gravel plains along the lines of drainage from the front of the glacial ice. Extensive acquaintance with peat bogs or a comparative study of the lists of plants from different regions will convince any careful observer that bogs are very different in character, and that not all of them have been formed in the same way. There may be a number of possible ways by which such accumulations of vegetable matter came about. Various such points of view and methods of classification have been suggested in a comprehensive study by DAVIS (11). As the process of bog development here seems similar to that of the peat deposits which the writer has observed at Michigan, the following brief account is given.

During the glacial period, most species common to bogs skirted the border of the ice sheet. Whatever plant or animal life existed was confined to the highlands east of the Scioto Valley, south of the Ohio River, and in the southern portion of this continent. At the margin of the ice sheet the conditions must have been quite circumpolar in character, similar to those of the barren grounds of the far north, that is, there prevailed short summers and long winters with frequent winds and storms. Whatever the causes

that resulted in such climatic conditions (4) with their change and with the progressive northeastward movement of the ice, an increasing land area became exposed, the topography of which is even now largely the inheritance of that time. While yet the entire surface of northern Ohio and the land north of it was buried under the ice sheet, the region about Columbus and Buckeye Lake was among the first to be laid bare by the retreating ice and water. The receding of the ice sheet was paralleled by the northeastward movement of more favorable weather conditions which initiated a migration northward of plants and animals along the glacial drainage channels, the earliest highways for the dispersal of many forms of life (1). As the ice and water continued to recede and the processes of erosion brought about better drainage and lower water levels, the flora and fauna followed down the slopes and began to encroach upon the ponds and lakes. The bog plants and their associates slowly had passed northward close to the base of the retreating ice, and hence were among the first to take possession of the new territory.

As has been stated, the test borings make it evident that the bog vegetation grew out from the shores, forming a floating mat; that sphagnum and cranberry appeared after the sedges and rushes had built up the surface mat; that filling in of débris from the sides continued slowly until the water had become shallow enough in places to enable shrubs and trees to occupy the area. The later phases of mature bog forests the writer has met very frequently in Ohio, and several interesting localities have been studied in connection with an inquiry on the peat deposits made for the Ohio Geological Survey.

While it is not clear how the preservation of the local bog island has come about, the present investigation has led to the conclusion that a well marked relationship existed between the type of peat soil considered with regard to its degree of disintegration, and the succession of plant associations covering it. As elsewhere in Ohio today, the firmer and well decomposed peat strata were covered sooner with forests, and were built up rapidly by an attendant sinking and shrinkage of the mat under the added weight of the growth and fall of trees and the vegetation of suc-

cessive seasons. On the other hand, the absence of logs and fallen timber in the peat of the sphagnum-cranberry zone points clearly to a relatively slow encroachment upon the open water by the plants. When inundation took place, only the coarsely fibrous and incoherent cranberry-sphagnum mat rose with the water level, and its vegetation survived.

As late as 1830 the bog was an extension from the mainland. After the formation of the dike, and the consequent rise of the water level, most of the mainland became inundated, leaving the bog completely an island. With its surface vegetation of mostly northern forms, the island is virtually a water culture on a large scale. None of the plants are dependent for any important part of their food on the mineral soil below the peat. Cranberry Island is, therefore, not to be considered merely as a case of the conversion of a forest into a marsh under the influence of an increased water content in the soil. The analysis of peat samples shows that the vegetation now growing upon the peat substratum represents quite fully a continuation of the former boreal flora. It presents today a somewhat disjointed distribution, but this has come about chiefly through recent repeated disturbances in the water level of the lake, through a settling and shrinkage of the peat soil, through the slow encroachment of the invading southern vegetation, and through the formation in places of a better and firmer soil.

The flora

For convenience three well marked plant zones may be pointed out, each of which is characterized by communities and groups of plants easily differentiated from the others. No attempt has been made to give full lists of plants, or to correlate the associations and successions mentioned with similar conditions elsewhere. Essentially the same order of succession and of arrangement of plants as has been described for northern bogs is not, of course, to be expected. The species are not always the same in the corresponding formations, but they are systematically related and closely similar in ecological structure.

A fuller floristic treatment is now in preparation, in which many of the features are described in detail.

THE BORDER ZONE

The outermost growth which immediately borders the open water and forms a more or less broken fringe around the island is for the most part hydrophytic. Along the southern shore it is dominated by the swamp loosestrife (*Decodon verticillatus*) and in places by cat-tails (*Typha latifolia* and *T. angustifolia*). This facies has for its principal and secondary species *Hibiscus Moscheutos*, *Sagittaria latifolia*, *Polygonum hydropiperoides*, *Ranunculus pennsylvanicus*, *Scutellaria galericulata*, *Lathyrus myrtifolius*, *Bidens cernua*, *Potentilla palustris*, *Campanula aparinoides*, *Galium triflorum*, *Cicuta bulbifera*, *Peltandra virginica*, and others. They are generally abundant, with *Decodon* and *Typha* forming a dense growth, which attains a height of 2–6 feet (0.6 to 1.8 m.) above the substratum. The vertical zonation is that of the differences in habit of growth of the individual species. The members differ widely from one another both in external features and in their demands upon the environment. In these regards the vegetative shoots adapt themselves little to the prevailing exposed conditions. Growing upon a peat substratum whose depth and physical characteristics are in every way like that of the other plant zones to be described below, the xerophytic type and quality are least marked in this vegetation. The well decomposed peat soil of the border zone permits here a luxuriant growth. The plants are able to secure all of their raw food materials from the water and air, and build their own substratum. The high water capacity of peat, the absence of a mineral soil, the smaller percentage of oxygen in the water, and the incoherency of the substratum afford no precarious conditions for growth. Here the toxicity of the substratum and the consequent physiological aridity are least marked. It is evident that dilution and the capacity of absorption of soluble salts by the humus soil along the margin (**8**, p. 403; **9**) corrects any harmful effect.

The *Decodon-Typha* association has a transition appearance, for a considerable admixture of plants such as *Rosa carolina*, *Cephalanthus occidentalis*, *Cornus canadensis*, *C. paniculata*, *C. stolonifera*, *Salix discolor*, *S. nigra*, *S. pedicellaris*, *Alnus incana* (?), *A. rugosa*, *Ilex verticillata*, *Prunus melanocarpa*, *Rhus Vernix*,

and various secondary dependent associates, occupy the firmer parts of the marginal zone and form an almost continuous fringe, the *Alnus-Rhus* association. In places it extends diagonally across the bog island as scattered dense thickets (fig. 4). This community of plants presents on the whole very little zonation within itself. It constitutes a zone of varying width, 5–30 feet (1.5–9 m.) and more, and attains a height of 8–12 feet (2.5–3.5 m.). Only in a few places along the southern shore this type of bog shrub formation is absent altogether and is replaced, as has been

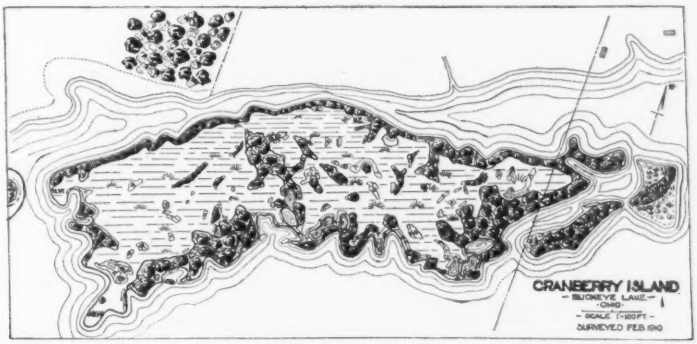

FIG. 4.—Map of Cranberry Island; surveyed February 1910; the divisions into plant societies as indicated by the map and the text are based on general characters of the vegetation; Δ, *Decodon;* *T*, *Typha;* the ponds on the island are shaded.

stated, by *Decodon* and *Typha*. The edaphic conditions of this part of the habitat seem to approximate those of the undrained swamps as described by COWLES (**6**). Nearer the lake there is a tendency toward the segregation of *Decodon verticillatus* and *Hibiscus Moscheutos*. Of the two, the former is more vigorous and occupies the deeper water. *Rosa carolina* prefers the outer border also, but clings quite closely to *Alnus incana* and *Cornus stolonifera*. Contemporaneous with the thicket-formers, various species of lianas invade the association. The mature thickets are often covered with an impenetrable growth of tangled vines of *Apios tuberosa*, *Solanum Dulcamara*, *Convolvulus Sepium*, *Ipomoea* sp., and *Cuscuta Gronovii*. *Cephalanthus occidentalis* does not

constitute a large part of the shrub formation. Together with *Decodon*, it is found frequently indiscriminately mixed with facies in the central zone. In fact, the differences in the formation are to be seen largely in the ratios between the numbers of individuals present, and not in their entire absence from either.

THE MAPLE-ALDER ZONE

With the maturity of the facies, a gradual change in the environmental conditions for the plants takes place. The annual leaf-fall covers the substratum with a visibly thicker layer of vegetable material rich in organic matter, and is followed by the growth of fungi and bacterial organisms favorable to succeeding plants through the formation of available nitrogen. Like snow and ice, the covering of fallen foliage reduces the extremes of soil temperature, suppresses the growth of *Sphagnum*, *Oxycoccus*, and similar plants from the adjoining central zone, and improves the production of a kind of humus of great significance to the animal life as well. Moles, earthworms, snails, and insects are not uncommon in this zone. The shade of the trees during summer and autumn checks extremes in evaporation, and thus reduces the transpiration from the herbs and shrubs beneath the trees. Through the combined action of these and various other agents, there is a corresponding rearrangement of some species and the disappearance of others. In places along the margin, the peat substratum is firmer, fairly well above the level of the lake, and comparatively better drained. These conditions are sufficiently established at the southeast side of the island to be characterized as the maple-alder zone. The bog tree formation is quite prominent, and though not extensive, it is still a strongly marked zone. The most conspicuous plants are large-sized maples (*Acer rubrum*), alders (*Alnus incana*, *A. rugosa*, *Ilex verticillata*), the chokeberry (*Prunus melanocarpa*), black cherry (*Prunus serotina*), and poison sumach (*Rhus Vernix*). Oaks (*Quercus palustris*, *Q. imbricaria*), ashes (*Fraxinus nigra*), and the silver maple (*Acer saccharinum*) are still relatively rare. The trees are surface-rooted. The roots do not penetrate to a depth of more than one foot (30 cm.). They spread out in all directions from the trunk, and are of sufficient

size and length to withstand the mechanical strains due to the action of air currents. The association is still an open community of plants and has four distinct vertical layers. The trees cast a relatively dense shade, in which grow seedlings and young trees of oak and maple, and a variety of shrubs and herbs. Most abundant are *Sambucus canadensis*, *Impatiens biflora*, *I. pallida*, *Rubus* sp., *Dianthera ovata*, *Viola blanda*, *Aspidium spinulosum*, *Osmunda regalis*, *Carex scirpoides*, *Aspidium cristatum*, *Habenaria clavellata*.

There is protection from strong air currents, and in the changed light, heat, and moisture conditions the plants offer a striking contrast to the vegetation next to be described. Many of the herbaceous and shrubby species occur only sparingly, and are really constitutents of the other societies of the border zone. In the numerous maple and oak seedlings the evidences are seen that the *Rhus*-alder consocies will not continue to occupy the habitat. The lowering of the water table due to the continued addition of débris and leaf-humus will hasten the advent of better soil, drainage, and shade conditions. *Alnus* and *Rhus* and their associates will find the new conditions unsuitable; they will disappear, leaving the zone more typically an oak-maple-ash formation. It is not probable that this coming society represents a climax forest for filled lake basins in this locality. There are limited portions on Cranberry Island which in the course of years are bound to revert to the central zone bog type, and that perhaps intermittently, for a settling and shrinkage of the numerous water pockets in the peat substratum will continue until all of the lower strata have become firm and compact. With continued accumulation of forest litter, the soil conditions will finally become drained and more xerophytic, to an extent that will constitute an ecological habitat considerably different from that existing in the neighborhood. Should the water level remain constant, the amount of upbuilding will be limited to the distance to which the water will rise through the accumulation of peat, and supply the growing plants at the surface with the necessary physiological water. It must not be assumed, therefore, that the development of a mesophytic forest could continue in the same direction indefinitely.

It is the lack of moisture, and not low temperature that will arrest the growth and reproduction of the plants concerned, and the disintegrating action of fungi and bacteria. This factor in plant growth, not previously important to the plants of the sedge, shrub, and thicket growth, then becomes operative selectively, leading to the establishment of a xerophytic plant association. At present, however, there is little indication of the appearance of an association of that kind; the climatic trend favors broad-leaved forests, and the supposed physiographic characteristics leading to a xerophilous climax association assume nowhere on the island any considerable importance.

There are conditions, however, which would indicate a reversion to a hydrophytic association. Adjoining the maple-alder zone on the southeast side are several extensive areas which do not respond quickly to changes in the water level; fig. 7 illustrates a part of such an area. Through the accumulation of vegetable débris, the replacement of air and other gases held in the mat by water, but especially through the increased load upon the surface of the mat after the heavier tree association became established, a settling and shrinkage of the peat occurred, which ultimately resulted in the sinking of the mat several feet below the water level. The cutting of the timber reestablished equilibrium and rejuvenation. The species now tenanting the mat indicate a tendency toward the development of a hydrophytic vegetation approaching the type of the border zone described. The marked difference between the vegetation of the central zone and the one establishing itself is worthy of special note. Except such portions of the fibrous mat as were long ago broken off from time to time by the action of wind and waves and drifted about as floating islands, the rejuvenated "sunken" mats, and such areas as annually rise in the early summer and disappear again beneath the water in late autumn concomitant with the "overturn" of the lake, show nowhere members of the cranberry-sphagnum zone. They illustrate most forcibly the fact that under these conditions a very different set of plants spring up and become dominant, although the true bog plants are near at hand.

THE CENTRAL ZONE

This zone is situated centrally on the island. It occupies the larger part of the area of the island, and in its floral structure is very distinct. The plants consist principally of *Vaccinium* (*Oxycoccus*) *macrocarpon* and several species of *Sphagnum*, with *Rhynchospora alba*, *Eleocharis obtusa*, *Aspidium Thelypteris*, *Dulichium arundinaceum*, *Carex comosa*, *Scheuchzeria palustris*, *Juncus canadensis*, *Eriophorum virginicum*, *Osmunda cinnamomea*, *Drosera rotundifolia*, *Menyanthes trifoliata*, several orchids, and other light-demanding forms variously grouped. The surface is characterized by hollows and elevations. The latter are due, in the opinion of the writer, to various causes; in part to the upward growth of sphagnum competing with cranberry, in other places because of a mutual protection which is afforded by the massing of forms of a similar height against excessive loss of water. In still other places, cranberry and sphagnum are growing beneath shade-producing forms, notably around ferns and invading maples and sumachs. Here they possess the ability to grow up in a manner giving rise to a thick soft mass, raised to a considerable height, more at the center than at the periphery. The maximum height to which cushions of sphagnum can grow is limited by the vertical saturation gradient of the water content in the air. The vertical level of this vegetation is otherwise fairly uniform, and varies only between 6 inches (15 cm.) and 1.5 feet (45 cm.) above the peat substratum, forming a low, dense, compact growth. The taller growth of grasses and sedges and the occasional bushes of *Gaylussacia baccata*, *Prunus melanocarpa*, and *P. arbutifolia* occur chiefly scattered and as open facies. They do not dominate the general vegetation enough to interfere with the transpiring organs of the plants at the lower level.

A more detailed study of the distribution of the species in the lower stratum shows habits of growth giving rise to vertical layers sufficiently defined to recognize vertical zonation; especially the differences of growth in height in the sphagnums, *Gaylussacia*, and *Vaccinium* in areas of varying physiological aridity show that the plants are adapted to a given average supply of water. But

in the zone under consideration, the differences in habit of form shade into each other, and in consequence are less distinct than those in the adjoining border zones. The prevailing grasslike growth-form, the general reduction in size of leaves assumed by the different species, is in harmony with the environment. It expresses itself not only in external features but also in the anatomical structure. As an ecological unit, the community of plants, identical in type, but different in floristic composition, exhibits well within itself the impress of its conditions of life.

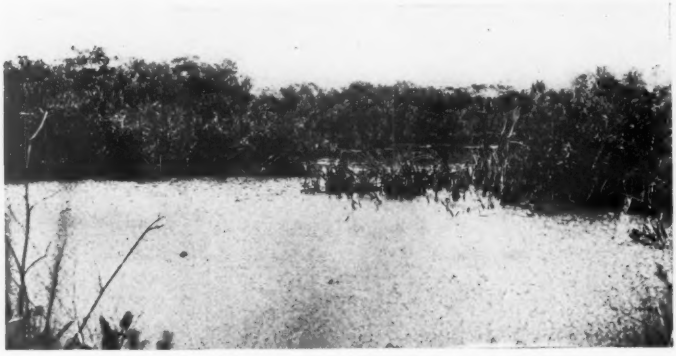

FIG. 5.—A pond in the cranberry-sphagnum association; *Decodon* is the most important mat former making the advance upon the water.

Differences in aerial functions would be therefore largely species characteristics as well as environmental.

That the plants are adapted to a given average supply of available water, but with great specific differences among themselves, is further seen in the frail growth of *Cephalanthus* and *Decodon*, in the small trees of *Acer rubrum* and *Rhus Vernix*, and in the stunted forms of various other invaders from the neighboring plant societies which occur scattered throughout this zone. For the past few years thousands of maple, sumach, and alder seedlings have been observed to sprout, and yet failed to succeed beyond the first year's growth. Of those which succeeded, the stunted growth, the numerous dead branches, the ragged crown of foliage,

are a clear instance of the fact that the resistance offered by the invaders to the toxic conditions of this habitat is, indeed, but slightly effective.

There are several small ponds in the cranberry-sphagnum zone in which the dominance of *Decodon* and *Typha* as important members of the border vegetation is especially to be noted (fig. 5). *Decodon* is particularly well adapted in making an advance out-

FIG. 6.—The last stage of a larger water area, now occupied by the advancing cranberry-sphagnum association.

ward upon the water by the manner in which the slender mature stems, that bend toward the water, curve at the tips. From the submerged part roots arise in considerable numbers, buds form, and new plants develop. The young plants remain moored to the parent plant for a year or two. As soon as the stools are built, they become the habitat of a number of plants such as *Bidens cernua*, *Polygonum hydropiperoides*, *Cyperus strigosus*, *Impatiens biflora*, *Peltandra virginica*, and others. These with *Decodon* and *Typha* seem, however, unable to persist, for dead stems of *Typha* and remains of stools of *Decodon* may be seen in

the cranberry-sphagnum association immediately behind this border vegetation. The last stage of a former large water area now occupied by the advancing cranberry-sphagnum association is shown in fig. 6. Cranberry and sphagnum build a mat and tufts of great compactness and gradually overcome and eliminate the swamp loosestrife (*Decodon*), cat-tail (*Typha*), *Peltandra*, and others. The advance of the mat out over the surface, even of open water, can be demonstrated by a series of such stages and

FIG. 7.—A sunken mat in the process of rejuvenation; the increased load upon the surface of the mat, especially after the heavier tree association became established, caused the sinking of the mat; the cutting of the timber reestablished equilibrium.

"last vestiges" indicating the existence of concentric zones of *Decodon* and *Typha* in quaking mats where formerly water occupied the area (fig. 4). The mats are floating, for test borings through them end abruptly in water which is quite free from fibrous material. The space of open water between the upper mat and the rest of the deposit below has frequently a depth of 4–5 feet (1.2–1.5 m.). In several places the peat below such mats is fine grained and well decomposed, not at all of a character that would indicate a transition structure from the coarsely fibrous to the well disintegrated, slightly fibrous deposit resting on the coarser mat below.

The sphagnum-cranberry formation is not to be regarded as an intercalation (**18**). The organic matter deposited by past generations of plants shows that sphagnums, cranberry, and their associates occupied this surface long before the maple-alder zone was formed. It is therefore an earlier and normal stage of succession, under conditions of development and a combination of factors which favored persistence and succession in that direction, and which are not suitable even today for the ecesis of a shrub-formation or for germination and growth of the seeds blown over in great quantities from the woodlots and fields surrounding the lake.

The vegetation in the central zone agrees very largely with plant societies in bogs and swamps of more northern regions. Many other "boreal" plants which were no doubt concerned in the early developmental stages of the local bog are now extinct. This is especially true of the pitcher plant (*Sarracenia purpurea*), the creeping snowberry (*Chiogenes hispidula*), wild rosemary (*Andromeda polifolia*), leather leaf (*Chamaedaphne calyculata*), labrador tea (*Ledum groenlandicum*), pale laurel (*Kalmia polifolia*), and larix (*Larix laricina*). The plants are still found in Ohio bogs north of here. A number of them have been recently transplanted and are now on the island in good condition.

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A MORPHOLOGICAL STUDY OF DIOSPYROS VIRGINIANA

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 145

STELLA M. HAGUE

(WITH PLATES I–III)

Diospyros virginiana, the northernmost representative of the tropical family Ebenaceae, grows abundantly in the southern states and as far north as the southern part of Illinois and Indiana. Cultivated trees are found also in the extreme northern part of those states. No report of any morphological work upon this family has been found, except a brief paper on "The seedless persimmon" in the report of the Proceedings of the Indiana Academy of Science for 1908. The material for this investigation was collected in 1906 and 1908 from cultivated trees at Decatur (Illinois), and from native trees near Springfield (Missouri), Topeka (Kansas), and Memphis (Tennessee).

Floral development

The winter buds are composed of numerous tough hairy scales enveloping a very rudimentary shoot. The flower buds develop upon this shoot during its rapid growth in the spring. At Decatur, in 1906, the buds began to swell and to become green the latter part of April. Young shoots gathered the first week in May bore flower buds in the early stages of development. On May 30 the shoots were 20 cm. or more long and the flowers were beginning to open.

So far as the trees from which material was collected were observed, they were dioecious and bore only imperfect flowers. One possible exception has been found recently. Near Auburn (Indiana) there is a cluster of staminate trees, originating apparently from one tree, that are reported to have borne fruit occasionally. The flowers were carefully examined in the spring of 1910, and no variations from the regular staminate type were found. Unless a pistillate tree has been cut away, it seems prob-

able that perfect flowers are borne some seasons, as has been reported from Kansas.[1]

The staminate flowers are smaller than the pistillate and in clusters (fig. 1), 16 fertile stamens surrounding the sterile pistil. The pistillate flowers are solitary, and usually contain 8 sterile stamens, but very often the number is greater.

The early stages of the development of the two flowers are the same. The floral cycles are generally preceded by a pair of bracts, though often there is only one (fig. 2). The calyx next appears (fig. 3) and becomes a massive enveloping cup before the other cycles can be seen, which appear in centripetal sequence (fig. 4). The corolla can be distinguished before the stamens, but they develop together in the typical sympetalous fashion. Occasionally the calyx or corolla has more than four parts; this is illustrated in fig. 6, in which the calyx has five divisions.

The stamens of the staminate flower fork (fig. 5), thus doubling the pistillate number (fig. 6); in the pistillate flower it is a common occurrence to find the number increased by the branching of one or more of the stamens. The fertile pistil contains eight ovules. The style is single, but the stigma is four-parted. Not many sterile pistils were examined; those that were had no ovules and a short imperfect style.

Megasporangium and megaspores

The ovule is anatropous and has two integuments (fig. 7), this last character being unusual among the Sympetalae. The mother cell can be distinguished by its size and conspicuous nucleus about the time the inner integument is first visible (fig. 8). Judging by the repeated appearance of this stage in the material, it is especially persistent. Only one mother cell occurs in a sporangium, and is always next to the outer layer of nucellar cells, no parietal cell being cut off. One complete figure of the first division of the mother cell was found in the spindle stage (fig. 9). Compared with the preceding conspicuous nucleus of the mother cell, the spindle is small and has very small and numerous chromosomes.

[1] The Industrialist, Kansas State Agricultural College, March 1904.

A portion of another figure showing the formation of the wall between the daughter cells was seen.

Four megaspores are formed in a linear row (figs. 10, 11), but it is not always complete, three cells not being uncommon. One exception to the usual arrangement was discovered, in which the outer daughter cell is divided by a vertical wall (fig. 12). As usual, the chalazal megaspore becomes the embryo sac (fig. 13).

Early stages of the embryo sac

The two and four-celled stages of the embryo sac were not found. At the eight-celled stage the sac is small, much longer than wide, and somewhat pointed at the micropylar end. When the sac is seen enveloped by the single nucellar layer, it appears decidedly cone-shaped, and is supported upon a stalklike portion of the nucellus as upon a pedestal (fig. 15). The growth of the sac does not obliterate this nucellar tissue until a comparatively late stage of the ovule. In the sac of fig. 14, which is the eight-celled stage in which the polars are differentiated, only seven nuclei are shown, and it seems quite probable that that is the full number for that particular sac, because there is much evidence that the usual number of nuclei is not always present. This conclusion is reached because of the conspicuous absence of antipodals. Three antipodals were found in one sac, but only after a long search. Extremely early disintegration would also account for the absence of these cells, but no evidence was found for this explanation.

The egg apparatus in the eight-celled stage shows nothing unusual. The three cells are in the ordinary position, and there is the customary differentiation of the cells in size.

In striking contrast to these two groups, the antipodals and egg apparatus, are the polars, which are large and conspicuous (figs. 21*a*, 21*b*), and are found either approaching or fusing in material gathered during the flowering time.

During the development of the sac the integuments become massive, and the innermost layer of cells of the inner integument becomes large and full of protoplasm, forming a tapetal layer com-

pletely enveloping the sac and extending around the stalklike nucellus and far up the micropyle (fig. 16).

The study of the sac is made difficult by the dense outer integument, through which killing fluids penetrate with difficulty, and also by the presence of chemicals which interfere with the stains. This last difficulty is especially true of the micropylar end of the sac, which when mature becomes a beaklike accumulation of a mucilaginous substance.

Pollination and fertilization

These studies have so far revealed only doubtful evidence of pollination and none at all of fertilization. Careful search has failed to show pollen tubes in the tissue of the style. The most positive evidence has been a few cases in which the mucilaginous substance has been divided in such a manner as to suggest a pollen tube penetrating the sac, and a few others in which there is the appearance of a swollen tip of a pollen tube within the sac. This evidence is discredited because the mucilaginous substance has been seen similarly divided too early for pollination, and the resemblance to the swollen tip of a pollen tube may be due to an incomplete or imperfect section of the stage shown in figs. 17*a* and 17*b*. Other slight evidence may be found in the presence of the spindle and chromosome-like bodies of figs. 19 and 20*b*. These may possibly have entered the sac by way of the pollen tubes or may have originated from the nuclei of the tube. The fusing polars which are so conspicuous have been carefully examined for a third nucleus but none has been seen.

The doubtful character of this evidence has naturally raised the question, whether pollination is essential to fruit and seed production. The field observations relating to pollination are limited and not very exact, but they suggest the possibility of an interesting problem. A tree in Decatur, from which material was collected in 1906, bears seeded fruit abundantly, though no staminate tree is known to be nearer than two miles. In order to see if the pollen was carried that distance or was essential, a branch was covered in the spring of 1909 during flowering time so as to prevent the

access of the bees. No fruit was borne on this branch, but was developed upon the neighboring ones. The details of this experiment cannot be vouched for, but until more careful ones are tried it is affirmative evidence for pollination.

On a fruit farm beyond the city limits of Decatur is a cluster of 6 or 8 trees, the largest of which is the parent of the smaller ones. The gardener reports that seedless fruit occurs on all these trees, but not in the same proportion. The fruit of the largest tree is usually many-seeded and only rarely seedless, but some of the smaller trees bear few-seeded and seedless fruit abundantly. No differences were noted among the flowers of these trees, or any when the prepared material was compared with that from native trees. The later stages are yet to be examined, for no collections have been made from the cluster after the flowering time.

The nearest staminate tree is not known. One was reported within a quarter of a mile, but two careful examinations of the region have failed to locate it. Since persimmon trees in bloom always swarm with bees, they are doubtless the pollinating agent. It does not seem probable that the bees avoid certain trees, but it is possible that the supply of pollen which they carry is limited, and is deposited most freely on those trees which from their position they visit first. The trees of the cluster which bear the larger proportion of abnormal fruit are the least exposed trees.

That the distance of the staminate trees does make a difference in the fruit is reported in the 1907 Yearbook of the Department of Agriculture, in which one variety is mentioned as characteristically few-seeded, and the observation made that this and other varieties have fewer seeds when grown at a distance from staminate trees.

In 1910 the Decatur trees were again visited. A severe frost in May killed the first buds, consequently the conditions that season were not normal. The city trees bore no fruit at all, and the cluster only a small proportion of its normal amount. The fruit on all the trees was smaller than usual, inclined to early decay, and almost wholly seedless. One lot of 33 contained only one seeded fruit; another of 12, two. The embryos were normal. This state of affairs suggests an indifference to fertilization, even

to pollination, as the stimulating cause of the development of the ovary into the characteristic persimmon fruit.

In the paper previously referred to on "The seedless persimmon," the seedless fruit is reported to occur most abundantly on the lowest branches of the trees. No differences were found in the flowers; all had a fertile pistil and sterile stamens. The examination of the embryo sacs brought out no evidence of pollination or fertilization. In one case cited, if pollen is transferred from the staminate trees, the bees must carry it three or four miles; this was not determined. Perfect flowers are suggested as a possible source of the pollen. Any attempt to explain or to suggest the problems of pollination involved is impossible until further observations are made.

Late stages of embryo sac; endosperm and embryo

The absence of evidence of pollination and fertilization has made impossible at present a connected account of the series of events in a normal seed-producing sac following the eight-celled stage, nor can these stages be surely identified, because the ovules of the seeded fruit frequently fail to develop into seeds, and since the normal course has not been determined, it is uncertain where the two diverge and what the differences are.

The entire ovule increases very rapidly in size after the corolla falls off, but no sign of an embryo was found for a number of weeks afterward. Material sent from Memphis is past blooming the latter part of May, but not until the last of June or the first of July can embryos be found easily in the fresh material. Long before this the sac has become densely filled with endosperm. Judging from the size of the sac, the first division of the primary endosperm nucleus follows closely on the fusion of the polars, and the other divisions follow rapidly after this (figs. 22, 23*a*, 23*b*).

The antipodal nuclei disappear after the eight-celled stage, but the micropylar nuclei undergo interesting changes. In fig. 17*a* there are three protoplasmic masses very distinctly differentiated. The middle one contains numerous, rather large, spherical, densely staining bodies. Because of its size, position, and

persistence in older sacs, this mass is surely the egg and the two other masses the synergids. Fig. 17*b* is another view of the same sac and shows the synergids more distinctly. Fig. 16 undoubtedly shows the two synergids, but no division of the surrounding protoplasm. In fig. 18 the egg appears with the spherical bodies regularly arranged; the small nucleus is a synergid. Fig. 19 is the micropylar end of a sac in which figures of dividing endosperm nuclei were seen. The large cell is the egg, near which are the spindle-shaped figures mentioned before. From their position it is possible that they are the remains of the disintegrating synergids. The large cell of fig. 24 is the egg at a later stage than the other figures show, because it is almost completely enveloped by the endosperm; numerous illustrations of this stage were found. No more distinct segmentation of the egg was seen than appears in fig. 25, in which the protoplasm is divided, but only one nucleus could be found, which makes it a doubtful case. Even after the egg is completely surrounded by endosperm, the deeply staining globules remain, but they and the whole egg seem to lose the prominence shown in fig. 24. However, this is partly relative owing to the increased size of the whole ovule. Figs. 20*a* and 20*b* show the curious chromosome-like bodies in the micropylar end of the sac; they are rodlike and twisted, resembling chromosomes, but not those of *Diospyros*, which are very small. The investigation of these phases of the life history of the persimmon will be continued in the hope that the complete sequence of events in the embryo formation will be found.

The youngest unmistakable embryo that has been seen consists of three cells (fig. 26). This embryo was in the extreme micropylar end of the sac, imbedded in endosperm. Its position agreed very nearly with that of the egg when surrounded by endosperm, but no proof could be found that it originated from that cell. Fig. 27 represents the embryo at a much later stage, but does not yet show differentiation into stem tip and cotyledons. Fig. 28 is a variation from the common type, and fig. 29 is the appearance of the embryo about the time it can be distinguished without a lens. One case of polyembryony was found (fig. 30), and one lot of material contained freak embryos, one of which is shown in

fig. 31, in which a second pair of cotyledons has developed upon one of the original pair.

Microsporangium and pollen

The studies of the stamens and pollen were made from material collected in 1906 from a single tree near Decatur. This tree bloomed a few days later than the pistillate trees from which collections were being made at the same time. The pollen formation was easily traced. The only difficulty encountered was in the late stages when the protoplasm is dense and evidently contains the same chemicals that interfere with the stains in the embryo sac.

Each stamen produces four sporangia, whose early stages were not traced because the earliest collections were made May 28, about a week before the flowers opened. At that date the sporangia contained large pollen mother cells surrounded by a single tapetal layer (fig. 33). The division into tetrads is shown in figs. 34 and 35. The figures are small and the chromosomes numerous, 30 at least. In the mature pollen grain more than one nucleus could be rarely distinguished, and that one not nearly so conspicuous as the nucleus of the tetrad (figs. 36, 37). It is very possible that the dense protoplasm frequently obscures the second small nucleus. A considerable difference in the size of the pollen grains was noted; this and the frequent presence of a single nucleus, together with the lack of proof of pollination, raise the question of the fertility of the pollen. This remains to be determined along with the other problems of pollination.

Summary

1. The flowers are developed on shoots of the same season's growth. The floral cycles appear in the following order: a pair of bracts, the calyx, the corolla and stamens, and lastly the pistil.

2. The ovule is anatropous and has two integuments. A single mother cell is formed beneath the outermost layer of the nucellus, from which four megaspores develop, the chalazal one becoming the embryo sac.

3. The embryo sac at the eight-celled stage is small, somewhat pointed at the micropylar end, and rests upon a stalklike portion of the nucellus. A tapetal layer of cells from the inner integument completely surrounds it. The egg apparatus in this stage is not conspicuous; the polars are large and striking in appearance; the antipodals are found with so much difficulty that it is probable that one or more of the cells is often lacking.

4. The studies of pollination and fertilization are not complete. Little evidence of pollination has been found and none of fertilization. The production of seedless fruit is probably involved in the problem of pollination.

5. After the flowers fall, the whole ovule increases rapidly in size. The egg enlarges and becomes filled with densely staining globules. The primary endosperm nucleus divides early and the endosperm fills the sac, and then crowds the inner integument quite up to the dense outer one.

6. The embryo is late in appearing. The earliest stage identified was a three-celled one in the extreme micropylar region. The tendency to variation seen in many of the stages is shown here in the two types found, the freak embryos and the case of polyembryony.

7. Pollen mother cells were found on a tree a week before the older flowers opened. The mother cells are large and the whole mass is surrounded by a single tapetal layer. The spindle in the tetrad formation is small, the chromosomes being 30 or more. The pollen grains show some difference in size, and frequently only one nucleus could be distinguished.

I am very much indebted to Professors JOHN M. COULTER and CHARLES J. CHAMBERLAIN for assistance in the preparation of this paper, and also to the many friends who have so generously supplied me with material.

AUBURN, IND.

EXPLANATION OF PLATES I–III

FIG. 1.—Diagram of a cluster of staminate buds.

FIG. 2.—A pistillate bud, showing enveloping bracts (*b*).

FIG. 3.—A pistillate bud, showing a single bract (*b*) and the beginning of the calyx.

FIG. 4.—A pistillate bud, showing calyx (*k*), corolla (*c*), stamens (*s*), and pistil (*p*).

FIG. 5.—A staminate flower, showing calyx (*k*), corolla (*c*), the two stamens (*s*), and pistil (*p*).

FIG. 6.—A cross-section of a pistillate flower, showing the unusual division of the calyx into five parts, the union of the corolla, and the four parts of the pistil; diagram.

FIG. 7.—An ovule with the two integuments.

FIG. 8.—The nucellus containing the mother cell, and showing the beginning of the inner integument (*i*).

FIG. 9.—First division of the megaspore mother cell.

FIG. 10.—The two daughter cells.

FIG. 11.—The four megaspores.

FIG. 12.—The four megaspores; the outer daughter cell divided by a vertical wall.

FIG. 13.—The functioning megaspore; the others disintegrating.

FIG. 14.—Embryo sac; polars differentiated.

FIG. 15.—Diagram of an ovule showing the relative size of the parts, the shape of the sac (*e*), the stalklike nucellus (*n*), and the massive integuments (*i*).

FIG. 16.—The micropylar end of the embryo sac, showing the synergids and the enveloping tapetal layer.

FIG. 17*a*.—Micropylar end of sac; synergids and egg.

FIG. 17*b*.—Same sac as 17*a*, showing fusing polars.

FIG. 18.—Micropylar end of sac; one synergid and the egg.

FIG. 19.—Micropylar end of sac; egg and spindle-shaped bodies.

FIG. 20*a*.—A detail of the micropylar end of a sac, showing the chromosome-like bodies and the egg filled with the densely staining globules.

FIG. 20*b*.—Same as 20*a*; chromosome-like bodies more clearly shown.

FIG. 21*a*.—Fusing polars.

FIG. 21*b*.—Fusing polars.

FIG. 22.—First division of the primary endosperm nucleus.

FIG. 23*a*.—Division of endosperm nucleus.

FIG. 23*b*.—Division of endosperm nucleus.

FIG. 24.—Egg almost surrounded by endosperm.

FIG. 25.—Egg; segmentation suggested.

FIG. 26.—Young embryo.

FIG. 27.—Young embryo.

FIG. 28.—Variation of type of embryo.

FIG. 29.—Shape of embryo at the time it can be seen without a lens; diagram.

FIG. 30—Polyembryony; diagram.

FIG. 31.—A freak embryo; a second embryo (c^2) developing on one of the first pair of cotyledons (c^1); diagram.

FIG. 32.—Diagram of a cross-section of an anther, showing the four sporangia.

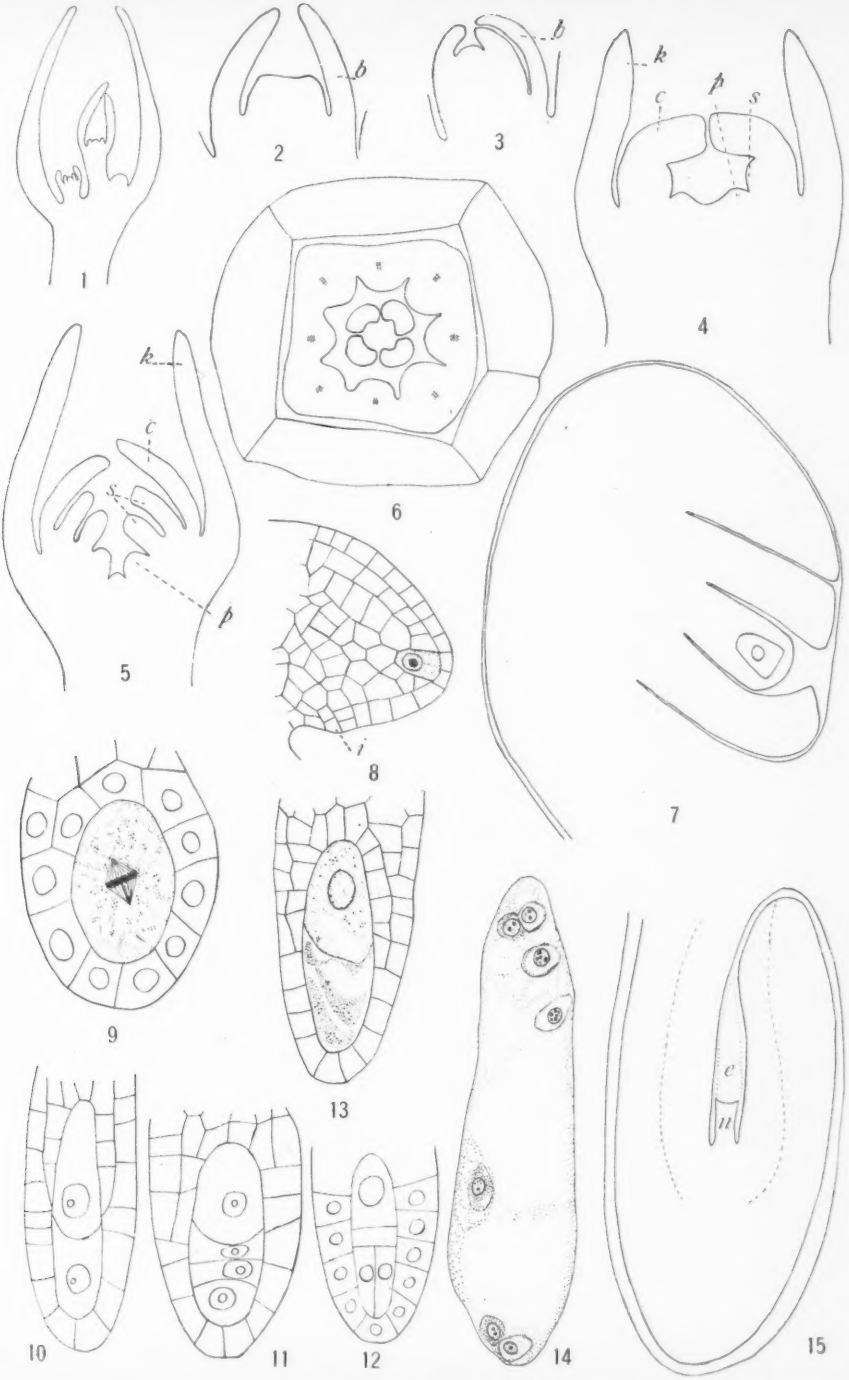
FIG. 33.—Pollen mother cells.

FIG. 34.—Formation of tetrads.

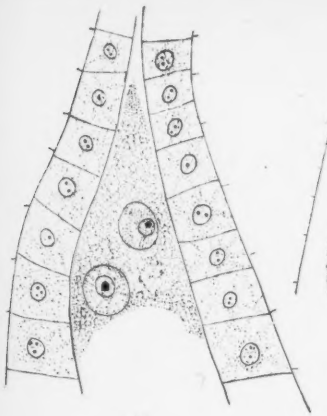
FIG. 35.—Tetrads.

FIG. 36.—Pollen grain; one nucleus.

FIG. 37.—Pollen grain; two nuclei.



HAGUE on DIOSPYROS



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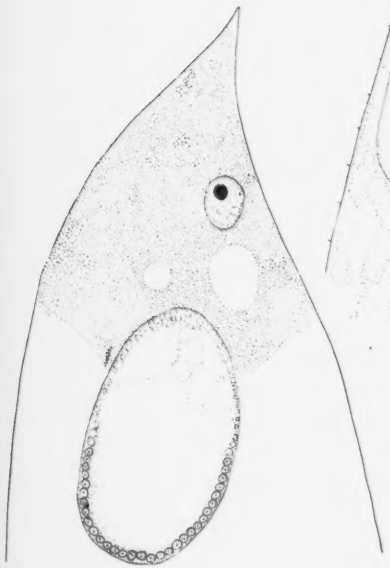
17*a*

20*a*



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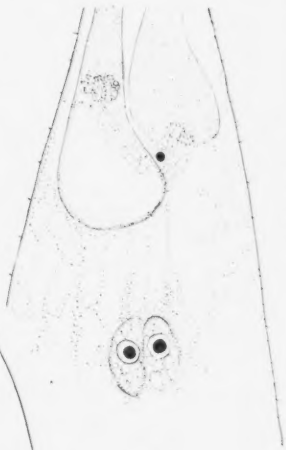

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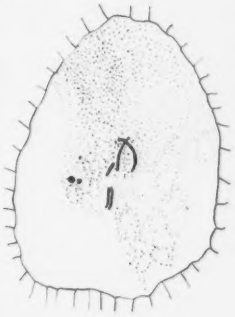
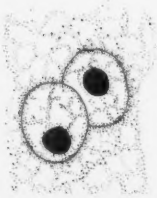


20*b*

21*a*



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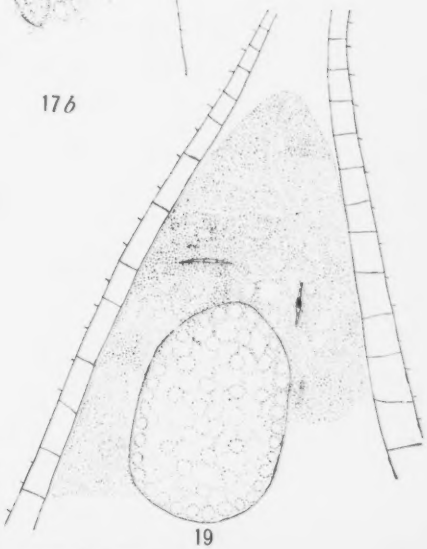

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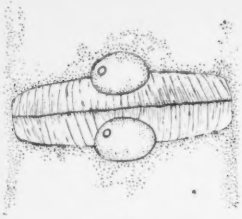
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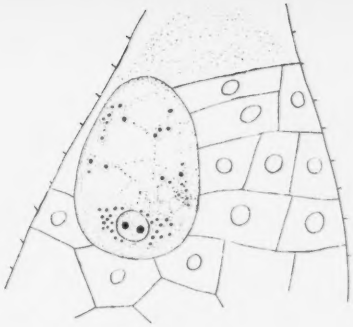
23a

23b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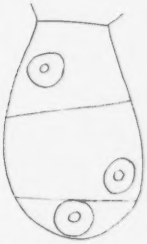
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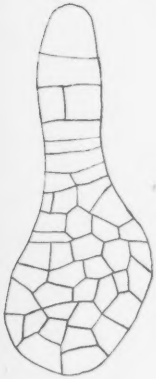
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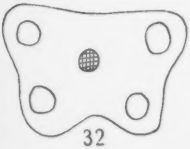
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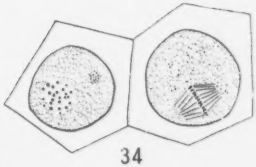
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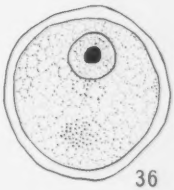
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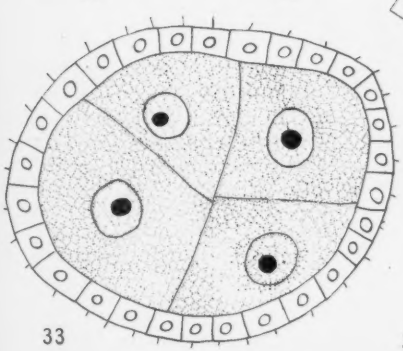
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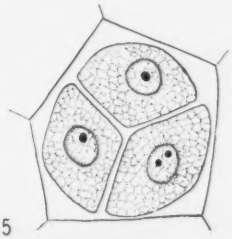
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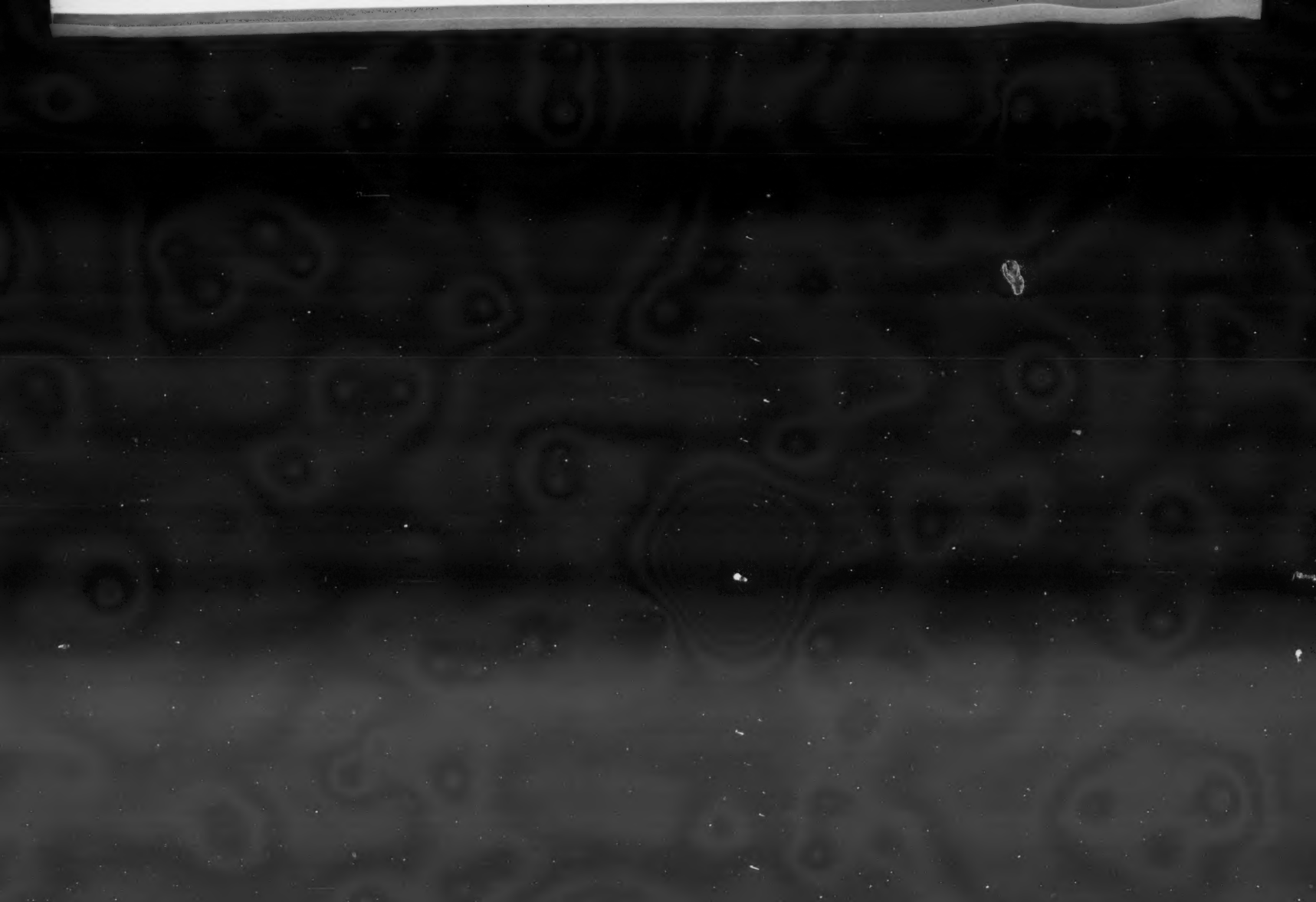
HAGUE on DIOSPYROS



UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXXIV[1]

JOHN DONNELL SMITH

Thouinia brachybotrya Donn. Sm.—Folia petiolo parum longiora trifoliolata, foliolis ovato- vel obovato-ellipticis utrinque acutis crenulatis supra puberulis subtus velutinis. Racemi axillares singuli simplices tenues breves densiflori. Samara subsemicircularis, alae latere interiore axin centralem 3-plo superante, exteriore loculum marginante.

Arbor 5-metralis, ramulis novellis petiolis racemis canescentibus. Foliorum juvenilium tantum visorum petiolus 1–2.5 cm. longus, foliola 4–5 cm. longa 16–20 mm. lata pellucido-reticulata, nervis lateralibus utrinsecus 10–12 furcatis marginem attingentibus, petiolulis 1 mm. longis. Racemorum pedunculus 3–6 mm. longus, rhachis 15–22 mm. longa vix 1 mm. crassa, pedicelli e nodulo piloso squama transversim elliptica intus glabra cincto orti 3–4 mm. longi rubiginosi. Sepala 1.5 mm. longa intus glabra. Stamina 1.5 mm. longa, filamentis inferne pilosiusculis, antheris glabris. Ovarii cano-velutini lobi subrhomboidei 2.5 mm. longi apice obtusi axin centralem subaequantes stylum trifidum inferne cano-velutinum paulo superantes. Samara abortione saepe solitaria 20 mm. longa 10 mm. lata velutina tota flabellinervata, alae latere interiore recta, exteriore arcuata, axe centrali incana 5 mm. longa, loculo 6 mm. longo, semine ovali 4.5 mm. longo, testa ferruginea. Petala in exemplis suppetentibus deficientia.

Ad ripas fluminis *Río Grande* dicti, Depart. Zacapa, Guatemala, alt. 230 m., Jun. 1909, *Charles C. Deam*, n. 6343.

Calopogonium phaeophlebium Donn. Sm.—Foliola ellipticooblonga utrinque obtusa vel obtusiuscula supra pilis appressis conspersa subtus praeter nervos primarios fulvescentes canosericea. Racemi pedunculati foliis longiores remote nodiferi, floribus 1–5-nis subsessilibus minimis. Calycis segmenta tubo paulo longiora. Vexillum calyce parum longius. Legumen fulvostrigillosum gracillimum polyspermum.

Herba volubilis, caulibus petiolis racemis retrorsum fulvo-pilosis. Foliola membranacea discoloria 5.5–8.5 cm. longa 2–3 cm. lata mucronulata, lateralia

[1] Continued from BOT. GAZETTE 49:458. 1910.

paulo minora inaequilatera subsessilia, nervis lateralibus utrinque 7–8 rectis simplicibus marginem attingentibus subtus conspicuis, petiolo communi 3.5–6 cm. longo, petiolulo terminali 6–8 mm. longo, stipulis stipellisque minute setaceis. Racemi pedunculo 2–5 cm. longo computato 12–20 cm. longi, pedicellis vix 1 mm. longis, bracteolis minute setaceis, floribus 7 mm. longis. Calyx fulvo-strigillosus 5 mm. longus, segmentis setaceo-acuminatis, duobus summis usque ad medium connatis. Vexillum violaceum 6 mm. longum alis carinisque longius, lamina fere orbiculari 3 mm. lata exauriculata. Stamen vexillare omnino liberum. Ovarium sericeum, stylo ad medium sensim incrassato. Legumen (in exemplis suppetentibus nondum satis maturum) deflexum lineare 5 cm. longum 3 mm. latum rectum apice falcatum, seminibus circiter 8–10.—*C. racemoso* M. Micheli proximum, floribus tamen *C. galactioidem* Benth. revocantibus. Ad ripas Laguna de Ayarza, Depart. Jalapa, Guatemala, alt. 2440 m., Sept. 1892, *Heyde et Lux*, n. 3742 ex Pl. Guat. quas ed. Donn. Sm.—Cuajiniquilapa, Depart. Santa Rosa, Guatemala, alt. 910 m., Sept. 1893, *Heyde et Lux*, n. 6096 ex Pl. Guat. quas ed. Donn. Sm.—Secanquím, Depart. Alta Verapaz, Guatemala, alt. 570 m., Jan. 1905, *George P. Goll*, n. 226.—Río Torres, San Francisco de Guadalupe, Prov. San José, Costa Rica, alt. 1170 m., Nov. 1894, *Adolfo Tonduz*, n. 8968.

Exemplum Gollianum in herbario Musei Nationalis sub numero proprio 860576 servatur.

Hauya (§ SESSILIFLORAE) **microcerata** Donn. Sm. et Rose.—Folia longiuscule petiolata obovata vel oblongo-obovata supra glabrescentia subtus cinereo-tomentosa. Flores inter maximos. Calycis laciniae tubo bis et ultra superatae pro rata brevissime appendiculatae. Capsula dorso ecarinata.

Arbuscula e schedula Tuerckheimiana, ramulis novellis et alabastris appresso-canoque pubescentibus. Folia primum ovalia supra pilosiuscula, demum 7–11 cm. longa 4–6 cm. lata abrupte breviterque cuspidata basi acuta venulis pellucida, nervis lateralibus subrectis utrinsecus 7–9, petiolis gracilibus 3–4 cm. longis tomentulosis, stipulis incurvo-subulatis 2 mm. longis glabris nigris. Calycis pubescentis tubus 8.5–10 cm. longus, laciniae 3.5–4 cm. longae, appendicula 3–4 mm. longa cano-velutina. Petala ovalia 33 mm. longa 23 mm. lata. Antherae 18 mm. longae filamentis aequilongae. Ovarium patule cano-velutinum 11 mm. longum, stigmate elliptico 5 mm. longo supra petala vix exserto. Capsula 5 cm. longa, seminibus deficientibus.

Santa Rosa, Depart. Baja Verapaz, Guatemala, alt. 1500 m., Sept. 1888, *H. von Tuerckheim*, n. 1423 ex Pl. Guat. etc. quas ed. Donn. Sm. (Typus).—Cuesta di Quililhá prope Purulá, Depart. Baji Verapaz, Guatemala, alt. 1400 m., Apr. 1905, *H. Pittier*, n. 155.—Canjob, Prov. Chiapas, Mexico, alt. 1350 m., Maj. 1904, *E. A. Goldman*, n. 923.

Exempla nn. 155 et 923 in herb. Musei Nationalis servantur.

Hauya (§ SESSILIFLORAE) **quercetorum** Donn. Sm. et Rose.—Folia ex orbiculari-ovali ovata cuspidata vel saltem acuta basi rotundata vel emarginata supra glabra, costa nervisque subtus ciliatis vel glabrescentibus. Calycis laciniae tubo subdimidio breviores longe appendiculatae. Ovarium pubescens. Capsula inter minores.

E schedula repertorum arbor. Ramuli glabrescentes foliorum cicatricibus arcte notati, partibus novellis cano-hirsutis. Folia subtus plerumque glauca 6–12 cm. longa 5–6.5 cm. lata, nervis lateralibus utrinque 8–9, petiolis pilosis vel glabrescentibus 1.5–2.5 cm. longis, stipulis aristuliformibus vix 1 mm. longis puberulis. Calycis pubescentis vel glabri tubus 7–9 cm. longus, laciniae 3.5–5 cm. longae, appendicula 10–13 mm. longa pubescente vel glabra. Petala 3 cm. longa. Filamenta 24 mm. longa antheris dimidio longiora. Ovarium 10–11 mm. longum, stigmate ellipsoideo 5 mm. longo paulo exserto. Capsula 3.5 cm. longa, valvis dorso planis, seminibus lanceolatis 15 mm. longis 5 mm. latis acutis, ala basi involuta incrassata latere altero producta.

In quercetis ad declivitates montis *Jumaytepéque* dicti, Depart. Santa Rosa, Guatemala, alt. 1850 m., Mart. 1893, *Heyde et Lux*, n. 4479 ex Pl. Guat. etc. quas ed. Donn. Sm. (Typus); Dec. 1892, *Heyde et Lux*, n. 4336 ex Pl. Guat. etc. quas ed. Donn. Sm.

Hauya (§ SESSILIFLORAE) **ruacophila** Donn. Sm. et Rose.—Folia orbiculari-cordata vel basi rotundata ovalia cuspidata supra glabra subtus costa nervisque dense cano-ciliata ceterum pilis deciduis conspersa. Calycis laciniae tubo subdimidio breviores appendicula elongata cano-ciliatae. Ovarium velutinum. Capsula inter majores.

Arbor mediocris, ramulis novellis velutinis. Folia 5–7 cm. longa 3–6 cm. lata, nervis lateralibus late patulis arcuatis utrinsecus 7–8 et costa subtus conspicuis, petiolis 12–25 mm. longis hirsutis vel velutinis, stipulis aristiformibus 2 mm. longis pubescentibus. Calycis pubescentis tubus 9.5–10 cm. longus, laciniae 5–5.5 cm. longae appendicula 10–12 mm. longa instructae. Petala elliptica 4.5 cm. longa 2.5 cm. lata. Filamenta 25 mm. longa antheris subaequilonga. Ovarium 13–15 mm. longum, stigmate globoso 8 mm.-diametrali vix exserto. Capsula 6 cm. longa, valvis dorso planis, seminibus oblongis 13 mm. longis 4 mm. latis obtusis, ala basi involuta incrassata latere altero producta.

In silvis ad montem *Volcán Acatenango* dictum, Depart. Zacatepéquez, Guatemala, alt. 1700 m., Mart. 1892, *John Donnell Smith*, n. 2528 ex Pl. Guat. etc. quas ed. Donn. Sm. (Typus).—Alotenango in declivitatibus praeruptis montis *Volcán di Fuego* dicti, Depart. Zacatepéquez, Guatemala, alt. 1300 m., Mart. 1892, *John Donnell Smith*, n. 2527 ex Pl. Guat. etc. quas ed. Donn. Sm.

Hauya (§ SESSILIFLORAE) **lemnophila** Donn. Sm. et Rose.—Folia oblongo-ovata vel -elliptica vel -obovata cuspidata vel saltem acuta basi rotundata vel obtusa supra glabrescentia subtus hirsuta. Calycis laciniae tubo subtriente breviores, appendicula pro rata longissima. Filamenta antheris dimidio longiora. Ovarium hirsutum. Capsula maxima.

E schedula repertorum arbor. Ramuli foliorum subtus nervi petioli uti ovarium patule cinereo-hirsuti. Folia maxima subcoriacea circumscriptione summe variabilia, adulta plerumque oblongo-elliptica 9–15 cm. longa 4.5–7.5 cm. lata nonnunquam subtus glabrescentia, nervis lateralibus subrectis utrinsecus 7–9, petiolis 2.5–4 cm. longis, stipulis aristiformibus 2 mm. longis pubescentibus. Flores e schedula albi. Calycis tubus 7.5–9 cm. longus, laciniae 4.5–5 cm. longae, appendicula in alabastro 16–18 mm. longa in flore 12 mm. longa. Petala 33–35 mm. longa. Filamenta 20 mm. longa, antheris 13 mm. longis. Ovarium 13–14 mm. longum, stigmate vix exserto. Capsula linearioblonga 7.5–8 cm. longa, valvis dorso planis, seminibus deficientibus.

Ad ripas lacus *Carrizal* dicti, Depart. Santa Rosa, Guatemala, alt. 1360 m., Maj. 1892, *Heyde et Lux*, n. 2936 ex Pl. Guat. etc. quas ed. Donn. Sm.

Hauya (§ PEDUNCULATAE) **lucida** Donn. Sm. et Rose.—Praeter foliorum nervos subtus glabrescentes omnibus in partibus glaberrima. Folia nitida obovata vel elliptica cuspidata basi acuta. Pedunculus ovario brevior, flore inter minores. Calycis laciniae tubo triente breviores, appendicula brevi.

Arbor 8–10-metralis, coma globosa aut dilatata. Folia juniora nervis subtus puberula, aetate provectiore glabra punctulato-pellucida 8–13 cm. longa 4.5–6 cm. lata, nervis lateralibus utrinsecus 8–9, petiolis 1.5–2.5 cm. longis, stipulis aristuliformibus aegre 1 mm. longis glabris. Pedunculus 4–7 mm. longus. Calycis tubus 4–6 cm. longus, laciniae 3–4 cm. longae, appendicula 3–4 mm. longa. Petala 3 cm. longa. Filamenta 17–19 mm. longa, antheris 20–23 mm. longis. Ovarium 9–12 mm. longum, stigmate supra petala paulo exserto. Capsula 3–4.5 cm. longa, valvis dorso planis, seminibus oblongis 11 mm. longis 3 mm. latis obtusis, testa 4 mm. longa, ala basi involuta incrassata latere altero producta.

Costa Rica, Prov. San José: Río Torres, San Francisco de Guadalupe, alt. 1170 m., Jun. 1893, *Ad. Tonduz*, n. 8005 (Typus); Apr. 1894, *John Donnell Smith*, n. 4801 ex Pl. Guat. etc. quas ed. Donn. Sm.; Oct. 1898, *Ad. Tonduz*, n. 7445 ex Pl. Guat. etc. quas ed. Donn. Sm.: Río Tilirí, Alajuelita, alt. 1000 m., Aug. 1894, *Ad. Tonduz*, n. 8915: Río Virilla, San Juan, alt. 1000 m., Aug. 1896, *Ad. Tonduz*, n. 7285 ex Pl. Guat. etc. quas ed. Donn. Sm.: San José, Nov. 1898, *H. Pittier* (numero deficiente).

Hauyae ad dignoscendas facilius species liceat omnium hucusque cognitarum conspectum proponere.

Sect. I. SESSILIFLORAE Donn. Sm. et Rose.—Flos arcte sessilis.
A. Calycis laciniae inappendiculatae. *H. elegans* Moç. et Sessé
B. Calycis laciniae appendiculatae.
1. Appendiculae 3–4 mm. longae.
a. Capsularum valvae dorso carinatae. *H. cornuta* Hemsl.
b. Capsularum valvae dorso planae. *H. microcerata* Donn. Sm. et Rose
2. Appendiculae 10–15 mm. longae.
a. Calycis laciniae tubo fere aequilongae. *H. Rodriguezii* Donn. Sm.
b. Calycis laciniae tubo multo breviores.
† Capsula 3.5 cm. longa. *H. quercetorum* Donn. Sm. et Rose
†† Capsula 7–8 cm. longa.
* Folia ex orbiculari-cordato ovalia. *H. ruacophila* Donn. Sm. et Rose
** Folia ex oblongo-ovato oblongo-obovata. *H. lemnophila* Donn. Sm. et Rose

Sect. II. PEDUNCULATAE Donn. Sm. et Rose.—Flos distincte pedunculatus.
A. Pedunculus ovario multo longior. *H. Heydeana* Donn. Sm.
B. Pedunculus ovario brevior vel ei subaequilongus.
1. Calycis laciniae inappendiculatae. *H. Bârcenae* Hemsl.
2. Calycis laciniae appendiculatae. *H. lucida* Donn. Sm. et Rose

Sicydium (§ EUSICYDIUM Cogn.) **Tuerckheimii** Donn. Sm.—Folia maxima oblongo-ovata sensim acuminata supra scabridiuscula subtus pubescentia. Flores masculi in paniculam amplissimam diffuse ramosissimam foliis reductis bracteatam digesti glabri minimi. Laciniae calycinae cum corollinis bis longioribus lanceolato-ovatae. Filamenta antheris aequilonga.

Suffruticosum, caulibus cirrhis paniculis sulcatis et petiolis glandulari-pubescentibus fuscis. Folia coriacea integra pedato-7-nervia transversim venosa 12–16.5 cm. longa 7.5–10.5 cm. lata, sinu basilari subrectangulari 1.5–2.5 cm. lato 1–1.5 cm. profundo, petiolis 2–3 cm. longis. Cirrhi 8–14 cm. longi apice bifidi. Paniculae, saltem eae florum masculorum, 3–4 dm. longae, ramis divaricatis bractea foliacea 1–3 cm. longa sustentis, inferioribus 1–1.5 dm. longis, bracteolis lanceolatis petiolatis 10–14 mm. longis, vel linearibus 2–5 mm. longis, pedicellis plerumque confertis capillaribus 1–2.5 mm. longis supra medium articulatis, floribus 3 mm.-diametralibus. Calycis tubus incrassatus patelliformis in sicco nigricans. Corollae laciniae 1 mm. longae reticulatae in

sicco flavicantes. Stamina 0.5 mm. longa. Flores feminini fructusque deficiunt.

In fruticetis, Cubilquitz, Depart. Alta Verapaz, Guatemala, alt. 350 m., Jul. 1907, *H. von Tuerckheim* (n. II. 1914).

Geophila pleuropoda Donn. Sm.—Tota pilosa. Folia petiolis bis longiora orbiculari-cordata obtusissima. Pedunculi pseudo-axillares folia aequantes vel bis fere superantes, floribus in capitulo subsessilibus quam bracteae involucrantes foliaceae longioribus. Calycis tubus segmentis triente brevior. Corolla calyce altero tanto vel ultra longior. Antherae brevissimae.

Caules petioli pedunculi bracteae flores pilis patentibus bulbosis articulatis purpurellis conspersi. Folia membranacea pellucida utrinque praesertim supra bulboso-strigillosa subtus purpurascentia 2–3.5 cm. longa atque lata, nervis lateralibus utrinque 5–6, petiolis 1–1.5 cm. longis, stipulis caducis. Pedunculi primum terminales deinde caule producto axillares singuli 3.5–5 cm. longi, capitulo hemisphaerico absque corolla 6–7 mm. alto 5–8-floro, bracteis 2 oblongo-ovatis vel oblongo-lanceolatis in petiolum decurrentibus 6–7 mm. longis cito caducis, pedicellis vix 1 mm. longis, floribus 4–5-meris bracteola lineari 3 mm. longa sustensis. Calycis tubus 2 mm. longus discum vix superans, segmenta lanceolato-oblonga 3 mm. longa erecto-patentia, alterna saepe minora. Corolla 10–12 mm. longa triente lobata, tubo toto infundibuliformi intus glabro, lobis ovato-oblongis obtusis erecto-patentibus. Filamenta 2 mm. longa, antheris oblongo-ellipticis 1 mm. longis semiexsertis. Stylus filiformis, ramis 2 mm. longis inclusis totis papillosis. Drupa ignota.

Secus semitam inter Secanquím et Sepacuite, Depart. Alta Verapaz, Guatemala, alt. 1220 m., Febr. 1905, *George P. Goll* (numero deficiente).—Typus in herbario Musei Nationalis sub numero proprio 860647 servatur.

Tabernaemontana (§ EUTABERNAEMONTANA K. Schum.) **Deamii** Donn. Sm.—Folia elliptico- vel obovato-lanceolata apice contracto-acuminata deorsum attenuata. Thyrsi laterales folia subaequantes. Calyx inter minimos fere partitus. Corollae tubus cylindraceus gracilis rectus calyce sexies longior lobos proprios subaequans. Antherae sessiles totae fere exsertae. Discus nullus. Stylus elongatus. Folliculi obovoidei cuspidato-acuminati basi acuti.

Frutex 3-metralis omnino glaber. Folia pergamentacea nitida 9–12 cm. longa 2.5–4 cm. lata apice ipso obtusiuscula in eodem jugo saepius inaequimagna, nervis lateralibus utrinque 16–19 sub margine arcuatis et venis erga lucem inspectis pellucidis, petiolis 7–12 mm. longis. Thyrsi 10–12.5 cm. longi, cymulis dichotomis, pedicellis 10–13 mm. longis basi bracteatis. Calyx 2.5 mm. longus, segmentis paene sejunctis obtuse ovatis basi 4–5-glandulosis.

Corollae in sicco albae tubus 15–16 mm. longus 2 mm.-diametralis faucibus pubescens ore tuberculis 10 munitus, lobi dolabriformes apice rotundati. Antherae coeruleae 3 mm. longae ultra medium bifidae. Stylus 10–12 mm. longus, stigmate 5-apiculato inferne membrana dilatato. Folliculi cuspide 1 cm. longa addita 6.5 cm. longi cartilaginei nitidi pallescentes 4-costati, seminibus ellipsoideis 5–7 mm. longis striatis ad hilum sulcatis, funiculis pulposis.—Secundum methodum Schumannianam gregi AaaII3** adscribenda.

Secus fluvium *Montagua* prope Gualán, Depart. Zacapa, Guatemala, alt. 190 m., Jun. 1909, *Charles C. Deam*, n. 6282.

Lisianthus quichensis Donn. Sm.—Folia lanceolato-oblonga utrinque subsensim acuteque angustata sessilia amplexicaulia. Cymae longe pedunculatae laxe longeque ramosae. Calycis elongati segmenta ecarinata. Corolla calyce 4-plo fere longior, tubo a basi circiter ad trientem altitudinis sensim angustato et ibidem staminifero subinde infundibuliformi, lobis brevibus erectis. Genitalia exserta.

Suffrutex bimetralis glaber, ramis ramulis inflorescentiae axibus teretibus pallido-stramineis, internodiis folia paulo excedentibus, nodis membrana lineari interpetiolari marginatis. Folia pergamentacea 10–13.5 cm. longa 2.5–3 cm. lata, nervis lateralibus utrinque binis parum manifestis. Cymae pedunculis 5–8 cm. longis computatis 9–17 cm. longae ter quaterve trichotomae, pedicellis 4–7 mm. longis. Calyx 10 mm. longus usque ad $\frac{2}{3}$ partitus, segmentis lineari-lanceolatis filiforme attenuatis hyalino-marginatis. Corolla in sicco flavicans 36–38 mm. longa, tubo tertia parte inferiore crebre nervato, lobis cuspidato-ovatis 5 mm. longis. Stamina ad 11–12 mm. supra basin corollae inserta, filamentis inaequilongis 22–26 mm. longis, antheris exsertis oblongis erectis muticis. Discus nullus. Ovarium oblongo-ovoideum 6 mm. longum, stylo stamina 4 breviora aequante, stigmate capitato obscure bilobo. Capsula ignota.—A. *L. acuminato* Perk. proximo differt praesertim foliis angustioribus, calyce elongato, genitalibus exsertis.

Río Negro, Depart. Quiché, Guatemala, alt. 1100 m., Apr. 1892, *Heyde et Lux*, n. 2921 ex Pl. Guat. etc. quas ed. Donn. Sm. (Sub *Leiantho brevidentato* Hemsl. olim distributus.)

Lisianthus meianthus Donn. Sm.—Folia oblongo-ovata superne tenuiter deorsum contractius acuminata sessilia amplexicaulia 5-plinervia. Cymae corymbiformes laxiflorae, floribus minimis. Calycis segmenta leviter carinata. Corollae hypocraterimorphae tubus ultra ovarium tenuis faucibus staminiferis vix dilatatus calyce atque lobis propriis bis circiter longior. Genitalia exserta.

Suffruticosus dense ramosus. Rami teretes cum ramulis et inflorescentiae axibus subquadrangularibus pubverulentes et fusci, internodiis elongatis, nodis linea elevata interpetiolari marginatis. Folia pergamentacea 6–10 cm. longa

2.5–3.5 cm. lata, nervis subtus conspicuis longe ascendentibus. Cymae obdeltoideae 7–11 cm. longae repetitus trichotomae, pedicellis vix 1 mm. longis. Calyx 4–5 mm. longus paulo ultra medium fissus, segmentis lanceolatis hyalino-marginatis. Corollae in sicco luteae tubus 10 mm. longus dimidio superiore tenuiter cylindraceus fibroso-nervatus, lobi oblongo-elliptici 4–5 mm. longi sub anthesi expansi. Stamina ad 2 mm. infra os corollae inserta, filamentis aequalibus 3.5 mm. longis, antheris nec recurvis nec apiculatis. Discus nullus. Ovarium calycem subaequans, stylo staminibus aequilongo, stigmate peltato. Capsula oblonga 7 mm. longa reliquiis fibrosis tubi corollae marcidae vestita.

Sacolal, Depart. Alta Verapaz, Guatemala, alt. 915 m., Jan. 1889, *H. von Tuerckheim*, n. 1436 ex Pl. Guat. etc. quas ed. Donn. Sm. (Sub *Leiantho saponarioide* Griseb. olim distributus.)

Solanum (§ MICRACANTHA Dun.) **purulense** Donn. Sm.—Folia bina ternaque integra nitida pilis sparsis stellatis scabriuscula, altero uti alterum paulo minus lanceolato utrinque praesertim superne acute attenuato, tertio 2–4-plo minore elliptico utrinque acuminato. Racemi laterales stellato-tomentosi, rhachi parce aculeata, pedicellis flore dimidio brevioribus. Calyx inermis.

Rami sarmentosi super frutices reclinati lignosi teretes 5 mm.-crassi aculeati glabri purpurascentes apice cum foliis nascentibus stellato-fulvoque-tomentosi, aculeis stramineis e basi compressa 2.5 mm. longa uncinatis 2 mm. longis. Folia dua majora 11–18 cm. longa medio 3.5–6 cm. lata, pilis utrinsecus valde dissitis, costa subtus arcte aculeata, nervis lateralibus utrinque 6–8 subtus parce aculeatis, petiolis 1–2 cm. longis dense aculeatis, folio tertio 3–6 cm. longo 1.5–3 cm. lato breviter petiolato. Racemi 5–6 cm. longi secundiflori, pedicellis 8–10 mm. longis cernuis. Calyx stellato-tomentosus hemisphaericus 4 mm. altus triangulari-dentatus. Corollae rotatae segmenta linearia 18–19 mm. longa 2 mm. lata extus stellato-tomentosa. Filamenta 1 mm. longa, antheris linearibus 12–13 mm. longis apice biporosis. Bacca ignota.—Ad *S. lanceaefolium* Jacq. accedens.

In fruticetis ad Purulá, Depart. Baja Verapaz, Guatemala, alt. 1600 m., Apr. 1907, *H. von Tuerckheim*, n. II. 1751.

Alloplectus metamorphophyllus Donn. Sm.—Folia quam maxime disparia, altero magno elliptico utrinque acuminato perlonge petiolato, altero nano stipulaeformi lanceolato-lineari coccineo prophylla dua aflora sibi ipso omnino similia fulciente. Corymbus in axilla folii majoris subsessilis umbelliformis dense congestiflorus, bracteis bracteolis calycis segmentis supra medium subulato-laciniatis coccineis praeter lineam dorsalem glabris.

Suffrutex in truncis putridis epiphytalis nodis radicantibus longe repens, caule striato glabrescente erubrescente. Folium in pare majus nascens

utrinque densissime stramineo-holosericeum, adultum praesertim subtus glabrescens membranaceum mucro-denticulatum 17 22 cm. longum 8–10 cm. latum, petiolo gracili 7–10 cm. longo glabrescente. Folium nanum cum prophyllis paulo altius sitis lateralibus sessile erectum filiforme productum 3–4 cm. longum 6–8 mm. latum membranaceum praeter lineam dorsalem glabrum. Corymbus subglobosus 2.5–4 cm.-diametralis, pedunculo 6–8 mm. longo et axibus pubescentibus, pedicellis 3–10 mm. longis, bracteis ovalibus vel oblongo-ellipticis 14–16 mm. longis, bracteolis lineari-lanceolatis 15–18 mm. longis subulato-productis. Calycis segmenta fere sejuncta aequalia lanceolato-linearia longe subulato-producta 12–16 mm. longa, laciniis 3–5 mm. longis. Corolla nondum satis evoluta pilosa calyce brevior leviter ventricosa basi vix gibbosa ore obliqua, lobis rotundis brevibus. Antherae liberae breves, loculis parallelis distinctis. Disci glandula solitaria obtuse ovata 2 mm. longa. Ovarium pilosum acuminato-ovoideum 3 mm. longum, stylo 5 mm. longo, stigmate bilobo. Fructus coriaceus glaber ovato-globosus 6 mm. longus indehiscens, seminibus funiculo capillari affixis. Flores evoluti ignoti.—Species anormalis.

La Palma, Prov. San José, Costa Rica, alt. 1500–1600 m.: *Adolfo Tonduz*, Sept. 1896, n. 10884; Aug. 1898, n. 12469: *William R. Maxon*, Maj. 1906, n. 364.

Besleria (§ PARABESLERIA Hanst.) **pycnosuzygia** Donn. Sm.—Internodia brevissima. Folium alterum altero subduplo majus coriaceum discolor integrum supra glabrum subtus puberulum oblique lanceolatum utrinque acutum, nervis lateralibus validis utrinsecus 5–6 sub angulo angusto longe ascendentibus. Pedicelli aggregati internodio petiolo flore paulo breviores. Corolla calyce subtriplo longior. Ovarium pilosum.

Suffrutex, caule simplice tetragono nodis incrassato, internodiis 1.5–2.5 cm. longis, partibus novellis canescentibus. Folium in pare majus 10–14 cm. longum 3.5–4.5 cm. latum inaequilaterale, nervis lateralibus subtus prominentibus supra impressis, petiolis 1–2 cm. longis. Pendunculus nullus, pedicellis circiter 6–8-nis 8–18 mm. longis puberulis. Calycis partiti extus puberuli intus pilosi segmenta oblongo-ovata obtusa 7 mm. longa integra margine scariosa, postico minore declinato. Corolla coccinea sericea 21–24 mm. longa, tubo recto superne leviter ampliato vix ventricosa basi defracto postice gibbo, lobis rotundatis subaequalibus. Stamina ad 4 mm. supra corollae basin inserta, antheris cohaerentibus transversim ellipticis, loculis orbicularibus. Discus subaequalis 2 mm. altus antice interruptus. Ovarium ovoideum 3 mm. longum, stylo 1.5 cm. longo. Fructus ignotus.

In silvis ad La Palma, Prov. San José, Costa Rica, alt. 1459 m., Sept. 1898, *Adolfo Tonduz*, n. 12545.

BALTIMORE, MARYLAND

APPARATUS FOR THE STUDY OF COMPARATIVE TRANSPIRATION

EDGAR N. TRANSEAU

(WITH FIVE FIGURES)

The quantitative study of the ecological factors of the habitat naturally leads to a similar investigation of the responses of the "growth-forms" to these elements of the habitat. Thus the investigation of the comparative evaporation of various local habitats has led to a complementary study of the comparative rates of transpiration of the plants occurring in them. In this latter work an effort has been made to obtain graphs of the hourly transpiration rates under a great variety of conditions of temperature, light, and humidity. For comparative purposes these data are being collected (1) by the synchronous exposure of several plants, and (2) by determining the ratios between the transpiration rate and the rate of evaporation from a standard vaporimeter.

It is evident that for conducting a study of this kind, in which data regarding the effects of stimuli and latent periods are essential, the determination of the water losses by the method of weighing at intervals of several hours is, to say the least, unsatisfactory. A very perfect apparatus for the automatic weighing and recording of evaporation rates has been described by GANONG in this journal.[1] For comparative purposes, however, several of these instruments are required, making the cost beyond the means of at least some laboratories. The following apparatus is essentially a modification of the Ganong transpirograph, developed for the special purpose of comparative work. Its efficiency, combined with its comparatively small cost, has made it seem worth describing in advance of the discussion of the data which are being obtained by its use.

The complete outfit, as shown in fig. 1, consists of a hygrothermograph, a chronograph, chemical balances, weight droppers,

[1] New precision appliances for use in plant physiology. BOT. GAZETTE **39**:145. 1905.

and irrigators. Of these the chronograph, the weight droppers, and the irrigators are new forms of well-known devices.

THE CHRONOGRAPH.—Where synchronous records are desired, it seemed that a chronograph having several pens to mark on the same sheet of paper would be more desirable than several separate instruments, not only on account of the decreased cost, but also

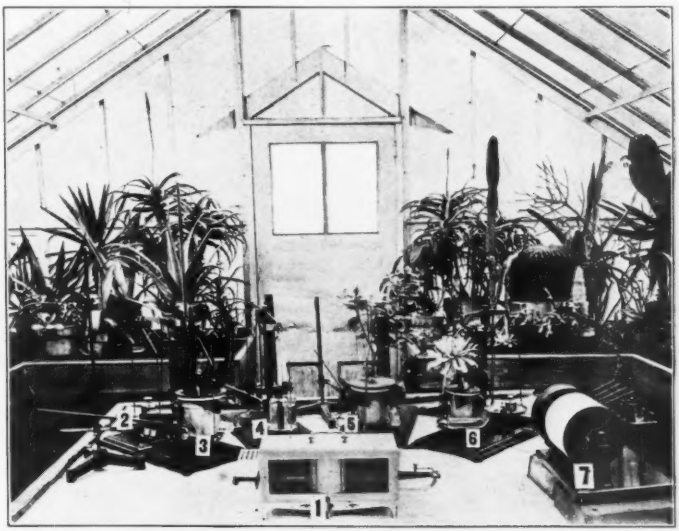


FIG. 1.—Complete apparatus for recording comparative transpiration data: *1*, combined hygrograph and thermograph; *2*, weight dropper; *6*, irrigator; *7*, chronograph.

because the errors of the clocks would be eliminated. The chronograph shown in fig. 1 has an eight-day movement attached to a horizontal cylinder 15 cm. long and 15 cm. in diameter. The record is made by pens which mark a continuous line except when drawn aside by an electro-magnet. At present the instrument bears four pens, but it is so constructed that four more may be added on the same side, thus increasing its capacity to eight synchronous records. By lengthening and shortening the hairspring the space traversed by the pen in one hour may be varied from 2 to 5 mm. In the

latter case the cylinder makes a complete revolution in about four days. A strip of ordinary millimeter cross-section paper is used for the record sheet. In class experimentation this recording clock has a variety of possible uses aside from this particular experiment.

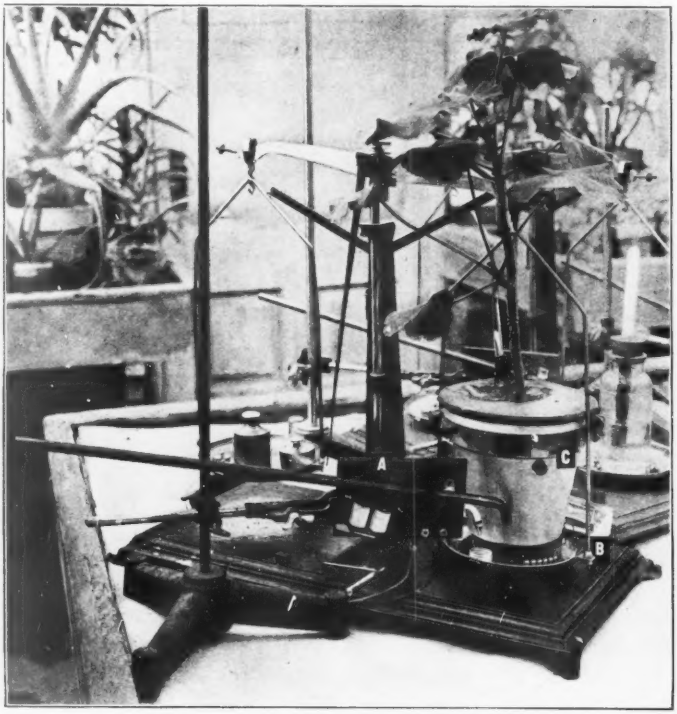


FIG. 2.—Weight dropper and circuit-closing device

THE WEIGHT DROPPERS.—As in the Ganong transpirograph, the recording of the water losses depends upon an electrically actuated mechanism which drops a definite weight in the form of a one-fourth-inch ball upon the scale pan whenever the pan reaches a certain height. As shown in fig. 2, the circuit-closing device consists of two platinum points just beneath the delivery tube

which dip into a small cup of mercury on the scale pan whenever a balance is established. The one gram weights are too heavy to obtain satisfactory records from many of the extreme xerophytes. For these plants I am using hollow brass balls standardized to 0.4 gm. These are not as light as could be desired, but they are better than the gram weights. To be very satisfactory for comparative purposes, the interval between records should not exceed two hours. Where great differences exist between day and night rates, I have used the fractional weights at night and the gram weights during the day.

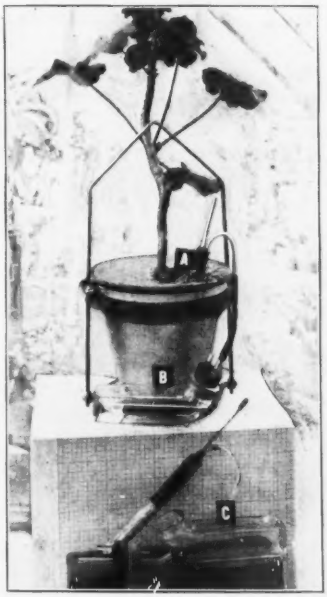


FIG. 3.—Details of the irrigator, showing porous cup, water reservoir, and connections.

THE IRRIGATORS.—Two points which became evident in the early experiments are that the water content of the soil of the plants to be compared must be essentially the same, and that the water content must be essentially the same throughout the experiment. The ordinary method of watering at 24-hour intervals did not give satisfactory results in some instances. In one experiment the ratio between two plants on successive days was reversed on account of differences in soil water content. To avoid errors of this kind the principle of irrigating plants by porous cups suggested by LIVINGSTON[2] was brought into use, and the apparatus shown in fig. 3 was constructed. It consists of a slender porous cup similar to those used in my vaporimeters.[3] This is readily introduced into the soil of a 3-, 4-, or 5-inch pot by removing a core of soil with

[2] A method of controlling plant moisture. Plant World 11:39. 1908.

[3] A simple vaporimeter. BOT. GAZETTE 49:459. 1910.

a cork borer slightly smaller than the porous cup. The cup is connected by glass and rubber tubing to a horizontal reservoir made of a flat-sided "specimen bottle." The reservoir is supported at the side of the scale pan by a light wire bracket, attached to a flat cork upon which the aluminum shell containing the plant rests. The second tube at the upper end of the porous cup affords an easy method of filling the cup. After the water has been drawn up, this tube is sealed with cement. The air needed to replace the water in the reservoir enters through the stopper by a capillary tube. By extending this capillary tube beneath the water level, the rate at which the water is removed may be approximated by the rate at which air bubbles enter. This may yield interesting results concerning the relative time of the absorption and transpiration maxima. It is of course open to the same objections as the Reinke method of determining the relative rate of photosynthesis in submerged plants.

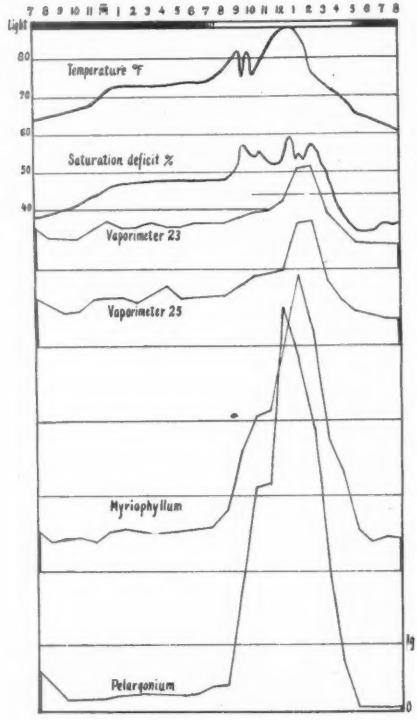


FIG. 4.—Graphs for part of the record of experiment 8.

The aluminum shells devised by GANONG[4] are very satisfactory for inclosing the pots. The 15 cm. shell seems to be the most satisfactory to use, regardless of the size of the pot, because of the larger volume of air inclosed. I have no quantitative data to prove

[4] BOT. GAZETTE 41:212. 1906.

this, but the plants appear to withstand the experimental conditions perfectly in this largest shell and not so perfectly in the more closely fitting ones. When the irrigators are used, it is convenient to have a 1 cm. hole in the side of the shell closed by a cork through which the air may be changed at intervals by means of a small bellows. This avoids the necessity of removing the roof from the shell during

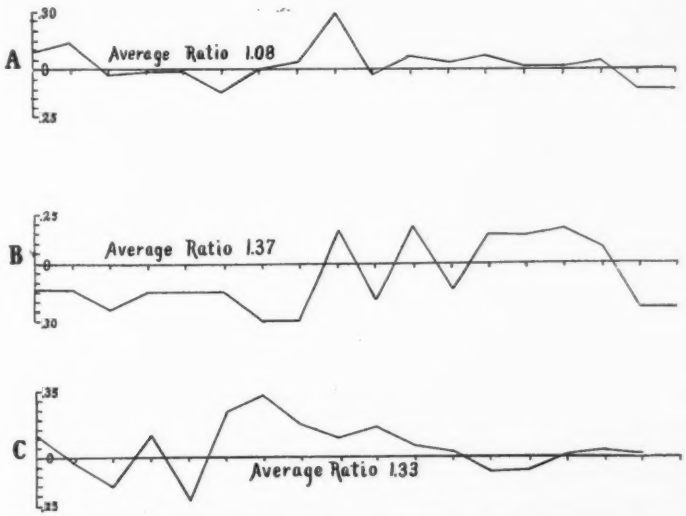


FIG. 5.—Departures from the average ratio between two synchronous records calculated to 2-hour periods: *A*, two vaporimeters; *B*, two irrigated pelargoniums; *C*, two pelargoniums watered at 24-hour intervals; average ratios calculated from the total water losses.

the experiment. The smaller pots are brought to the upper level of the shell by being placed on a strip of aluminum bent in the form of a W. This raising of the pot above the level of the water reservoir is necessary to prevent flooding of the soil.

In constructing the graphs from the actual records and in calculating the ratios, an engineer's slide rule has been found to be a great time saver. Fig. 4 shows the complete record for a portion of experiment 8.

To determine to what extent two records may be expected to

coincide by this method of recording, six experiments of two to five days' duration have been performed. The graphs shown in fig. 5 exhibit the actual ratios for 2-hour intervals in comparison with the average ratio for the entire experiment, for synchronous records of two vaporimeters (*A*), two irrigated pelargoniums (*B*), and two pelargoniums watered at 24-hour intervals (*C*). These partial records are sufficient to show that variations in the ratios between records must be greater than 0.3 in order to be significant. It will be readily seen that the variations in the actual records sufficient to produce this variation in the ratios are very small fractions of a gram in most instances. There are various explanations for these minor irregularities: the impossibility of estimating the hourly loss accurately when the gram-interval extends over several hours; shadows made by the framework of the greenhouse; differences in exposure to light; differences in irritability, etc. Whatever their causes, they must not be overlooked in comparing plants of different species and different habitats.

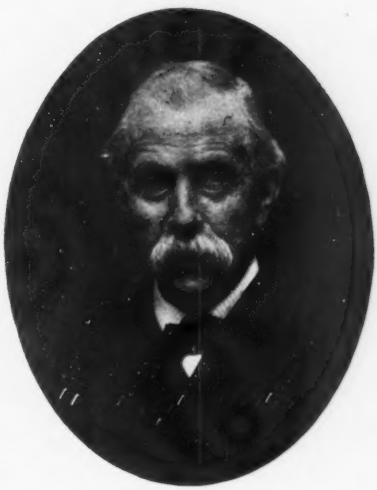
EASTERN ILLINOIS STATE NORMAL SCHOOL
CHARLESTON, ILL.

BRIEFER ARTICLES

EDWARD PALMER

(WITH PORTRAIT)

Dr. EDWARD PALMER died at his home in Washington, D.C., April 10, 1911, after an illness of a few days. He was an exceptional explorer and collector, who in the field of botany alone is distinguished as the discoverer of 1,162 new species of flowering plants, with many more of his last collecting still remaining to be described. At least 200 plants discovered by him bear his name, and will continue as witnesses to his wonderful activity.



He was the son of a professional florist and horticulturist, of Hockwold cum Wilton, in the county of Norfolk, England, where he was born January 12, 1831. Coming to this country at the age of 18 he settled at Cleveland, Ohio, where he formed the acquaintance of Dr. JARED KIRTLAND, one of the most eminent scientists of his day, and one of the earliest members of the American Academy of Science. From him he learned the art of collecting and preserving objects of natural history, thus laying the foundation of his future career, and through KIRTLAND'S influence he was in 1853 appointed naturalist of the "Water Witch," on her celebrated expedition to Paraguay, which led to our war with that country.

After his return to the United States, he was appointed collector in the Geological Survey of California, paying especial attention to the marine invertebrates of the California coast. In 1862, when President Lincoln called for extra troops, he offered his services to his country, and

after a time was appointed acting assistant surgeon at various posts in the West and Southwest, continuing to serve after the close of the war on frontier stations in the Indian country in Arizona and the Indian Territory. In connection with his work of attending the sick, he familiarized himself with the properties and uses of the medicinal herbs growing in the vicinity of his station, and he occupied his moments of leisure in making collections of animals and plants for the Smithsonian and other institutions.

In March 1869 he was sent by the Commissioner of Agriculture on a mission to New Mexico and Arizona, to report on the agricultural resources, commercial products, climate, and fertility of the soil, and the general habitable features of the Southwest. He afterward carried on archaeological investigations in southwestern Utah, and made extensive botanical and zoological investigations in that region, assisted in his work by a circular letter given him by BRIGHAM YOUNG. The Commissioner of Agriculture, HORACE CAPRON, in his report for 1870, called special attention to the value of his work, and he was congratulated upon his success by such eminent botanists as Professor ASA GRAY, Dr. TORREY, and Dr. ENGELMANN, all of whom considered themselves fortunate in having valuable material collected by him.

From a scientific point of view, the most important exploration made by him was that of Guadalupe Island, never before visited by a naturalist. The bearing upon evolution of the remarkable fauna and flora of this island in the Pacific Ocean, off the coast of Lower California, is almost as important as that of the animals and plants of the Galápagos Archipelago, as demonstrated by DARWIN. Every bird in his collection from Guadalupe, except a single sea bird, proved to be new to science; and among the plants collected at this time there were 21 new species, the greater part of which have never since been found elsewhere.

Other important collections were made by him in southern California and across the border in Lower California. Here, in a great canyon of the Cantillas Mountains, he discovered a plant which proved to be the type of a new genus, named in his honor *Palmerella* by Professor GRAY, who stated that he did so in acknowledgment of Dr. PALMER'S "indefatigable and fruitful explorations of the botany of the southwestern frontiers of the United States, from Arizona to the islands of Lower California, in which region he has accomplished more than all his predecessors."

The latter part of Dr. PALMER'S life has been devoted chiefly to exploration in Mexico, and the results have been published chiefly in

the Proceedings of the American Academy of Arts and Sciences, and in the publications of the United States National Museum. His collections, both botanical and ethnological, have been remarkable, not for the prettiness of the various objects, but for the completeness of the material and the care shown in his notes.

He continued his chosen work to the very end. His last exploration was in 1910, in the vicinity of Tampico, on the gulf coast of Mexico. After his return he occupied himself in assorting and distributing his material. On the occasion of the eightieth anniversary of his birth, the Botanical Society of Washington held a special meeting in his honor, at which a paper on his life and work by the author of the present sketch was read, together with letters written by various eminent men of science not residing in Washington. During the meeting of the society Dr. PALMER was seated in the place of honor, and at the close of the exercises he was presented with an appropriate birthday gift as a token of the appreciation of the members of the society of his important life-work. The venerable traveler received the congratulations of those present with tears streaming down his cheeks, doubtless realizing that this must be his valedictory.—W. E. SAFFORD, *Department of Agriculture, Washington, D.C.*

DEHYDRATING WITH ALCOHOL

(WITH FOUR FIGURES)

The difficulty which undergraduate students who take courses in histology find in giving regular attention to dehydration, led me to a search for an automatic method. Osmotic means were rejected because they are uncontrollable and give no indication of the stage of the process. Work on the principle of slowly adding alcohol of increasing strength to the tissue developed the simple apparatus shown in fig. 1. During the past two years this apparatus has been used for dehydrating all kinds of plant tissue for histology and embryology. It has also been used instead of glycerin in preparing algae to be mounted in Venetian turpentine.

The alcohol from the supply bottle drops from the lower end of the "capillary" *v* into the thistle tube, which conveys it to the bottom of the mixing tube *B*. The alcohol diffuses with the water in *B*, and the increase in volume is carried to the dehydrating tube *C* through the connecting tube *x*. Naturally, as more alcohol is added to *B*, the strength of the liquid passing into *C* increases, but as that in *B* is always

only slightly stronger than that in *C*, the tissues which are placed in *C* are not injured. In cases where extraordinary care is needed, it may be desirable to keep the tissues some distance from the opening through which the alcohol enters *C*. The siphon *y* removes the excess of

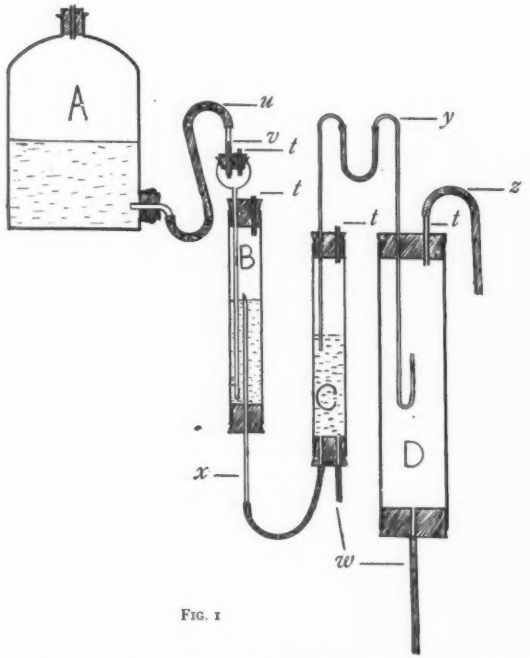


FIG. 1

FIG. 2

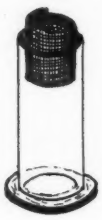


FIG. 3

FIGS. 1–3.—Fig. 1, *A*, supply bottle; *B*, mixing tube; *C*, dehydrating tube; *D*, waste tube; *t*, *t*, capillary tubes (air vents); *u*, supply tube; *v*, "capillary"; *x*, overflow; *y*, siphon; *z*, tube for starting siphon; fig. 2, "Capillary" on a larger scale: *n*, large tube; *m*, smaller tube, drawn to capillary (*p*) and sealed into lower end of *n*; fig. 3, washing jar with gauze neck.

dilute alcohol from *C*. The bent end of the siphon in the waste tube *D* prevents the automatic emptying of the siphon. When the apparatus is to be used, tissues and water are placed in *C*, and an equal volume of water is placed in *B*. The overflow *x* and the siphon *y*, which is filled by withdrawing the air from *D* through the tube *z*, are set to keep these volumes constant. The flow of alcohol is started by remov-

ing the "capillary" and supply tube from the thistle tube and letting them hang downward from the supply bottle for a minute to expel all the air from them.

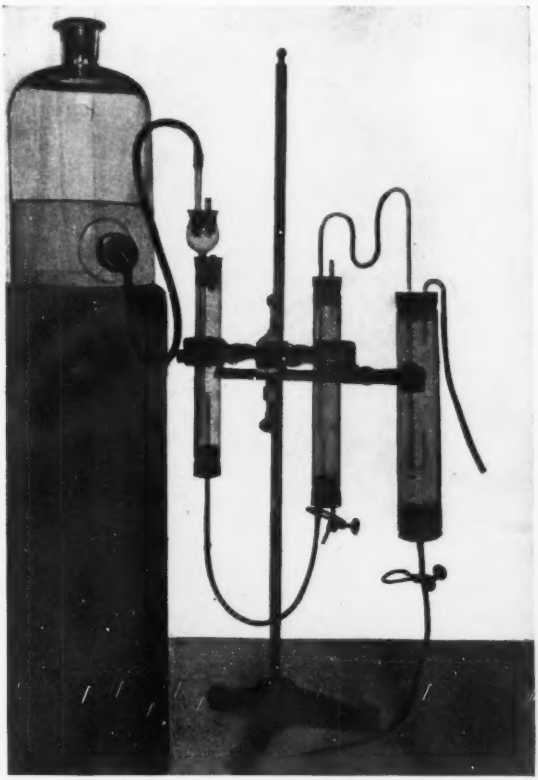


FIG. 4.—Photograph showing supports: to the stem of the double burette clamp, which holds the mixing and dehydrating tubes, is attached a single clamp which holds the waste tube.

Mathematical calculations, as well as numerous picnometer tests, show that the percentage of alcohol in *C* increases very steadily to about 75 per cent. Calling the contents of *C* one volume, the picnometer tests show that two volumes of 95 per cent alcohol will raise the strength of that in *C* to 70 per cent, three volumes to 85 per cent, and four to 92

per cent. However, most tissues may be taken from 85 per cent alcohol and covered with that remaining in *B*, and then transferred from that to either 95 per cent or absolute alcohol.

The flow of alcohol is insured against varying vapor pressures by the short capillary tubes in the stoppers which close the upper ends of the larger tubes, or if suitable capillary tubing cannot be obtained ordinary glass tubes nearly sealed at both ends will do quite as well. In either case the slightest amount of water in them renders them worthless. The "capillary" is shown at *v*, and enlarged in fig. 2. It is made by sealing within a larger glass tube a small one first drawn out to a very fine capillary. With a head of 40 or 50 cm. it should allow several drops of alcohol to flow per minute. If the flow is too slow, the small end of the fine capillary may be broken off with a pair of forceps. Otherwise the flow is regulated by raising either the supply bottle or the remainder of the apparatus, which is clamped on the ring stand. As a drop of alcohol from *v* per minute means 1 cc. per hour, and most material may be dehydrated in 40 hours or less, it is easy to adjust the flow, and the apparatus needs no further attention until its part of the process is complete. *B* and *C* may each conveniently be ordinary glass tubing 15 cm. long and 2.5 cm. in diameter. *D* is of similar material twice this diameter and 5 cm. longer. It is very convenient to have all three of these tubes graduated. The supply tube should be at least 6 mm. inside diameter, so that, when starting, the alcohol will readily replace the air in it; but, as the contents of the other connections are added to the waste alcohol and dehydration is delayed by the contents of *x*, these should not be over 1.5–2 mm. inside diameter. It seems that only the best antimony rubber tubing will withstand alcohol. Ordinary physicians' catheters, one large and two small, will furnish all of this tubing that is needed.

In practice it is convenient, after killing is complete, to tie the tissue with a label number in a square of fine silk gauze (chiffon). Knots are unnecessary; after the corners of the gauze are brought together a half dozen turns of very fine cotton thread will hold very well. A number of samples may then be washed very effectively under a small tap, in a jar the neck of which is provided with a cylinder of wire gauze as shown in fig. 3. After washing, the samples are transferred to the dehydrator and may afterward be kept in one or at least very few dishes until infiltrated with paraffin. The silk gauze also protects the samples from the air while they are being transferred to the imbedding dish, where it may be cut and the pieces of tissue and label properly arranged.—W. A. WULLSCHLEGER, *Nebraska Wesleyan University, Lincoln.*

CURRENT LITERATURE

MINOR NOTICES

Die Pflanzenstoffe.—WEHMER[1] has made readily available the known facts about the plant products (chemicals, drugs, enzymes, etc.) of the phanerogams. The plant families are arranged in the natural order, and under each the genera and species of which we have any chemical knowledge, along with the facts known and citations of literature establishing the facts. On the purely botanical side many facts of distribution are recorded. The work will prove of great value to plant chemists, pharmacists, and plant physiologists. A full index of the chemicals mentioned and a second one of the raw materials and plants greatly enhance the value of the book.—WILLIAM CROCKER.

Micrography of Javanese woods.—The third part of JANSSONIUS' micrography of the woods of Java has appeared,[2] and apparently completes this very laborious work, as it contains a general index to the two volumes. The plan of the work was described in the notice of the first part,[3] and a notice of the second part[4] indicated the further extension of the work. The present part, beginning in the midst of Meliaceae and closing with Moringeae, contains 100 species, the total for the two volumes being 329. Detailed descriptions of the vascular elements of so many species, including lists of reagents, sections, and material in each case, and also references to literature under each species, represent an amount and kind of work that few would care to undertake.—J. M. C.

Prodrome de la Flore Corse.[5]—Notwithstanding the long series of valuable contributions to systematic botany, both floristic and monographic, by which BRIQUET has enriched scientific literature, it is probable that he is chiefly

[1] WEHMER, C., Die Pflanzenstoffe botanisch-systematisch bearbeitet chemische Bestandteile und Zusammensetzung der einzelnen Pflanzenarten Rohstoffe und Produkte Phanerogamen. 8vo. pp. xvi+937. Jena: Gustav Fischer. 1911. *M*35.

[2] JANSSONIUS, H. H., Mikrographie des Holzes der auf Java vorkommenden Baumarten; im Auftrage des Kolonial-Ministeriums unter Leitung von Dr. J. W. MOLL bearbeitet im Anschluss an "Additamenta ad cognitionem florae arboreae javanicae auctoribus S. H. KOORDERS et TH. VALLETON." Dritte Lieferung. 8vo. Vol. II, pp. 161–540. *figs. 49.* Leiden: E. J. Brill. 1911. *M*6.

[3] BOT. GAZETTE **43**:345. 1907.

[4] *Ibid.* **47**:416. 1909.

[5] BRIQUET, JOHN, Prodrome de la Flore Corse, comprenant les résultats botaniques de six voyages exécutés en Corse sous les auspices de M. EMILE BURNAT. Vol. I. Geneva: Georg & Co. 1910.

known, in America at least, by the devoted attention he has given to the cause of a better international agreement on the controversial subject of nomenclature. As reporter-general of two international congresses, he has won universal admiration for clarity and fairness, and has gained the warmest gratitude of his colleagues for the exceptional efficiency and energy, which, with great self-sacrifice, he brought to bear upon an exceedingly intricate, time-consuming, and unremunerative task.

It has been generally known that BRIQUET for the last ten years or more has been engaged, notwithstanding the serious interruptions to which we have alluded, in an intensive study of the Corsican flora. In order to gain ample collections and a first-hand familiarity with the floristic conditions, no less than six expeditions to Corsica were made by him and his associates. Not only were the more accessible parts of the island repeatedly visited, but the wilder portions of the interior, including primitive woodlands, still infested by brigands, were traversed and examined.

The publication now at hand is the first volume of what has been modestly styled a *Prodrome*. It is an imperial octavo of something over 650 pages, and contains, besides prefatory matter and bibliography, a critical catalogue of the vascular plants of Corsica from the Hymenophyllaceae to the Lauraceae, including 722 species and many varieties. Under each, the citation of literature, synonymy, and exsiccatae is exhaustive. Habital notes and comments on distinctive characters, distribution, environment, etc., abound, and at points keys are introduced to elucidate distinctions between plants of the Corsican flora and their nearest relatives found elsewhere.

Without the slightest depreciation of its other and more scientific merits, it may be safely said that no small part of the interest attaching to BRIQUET'S work will be found in the fact it exemplifies, probably in a higher degree than any other flora published to date, the conscientious application of the international rules of nomenclature by one specially trained in all their shades of meaning and intricate details.—B. L. ROBINSON.

NOTES FOR STUDENTS

Genetic studies in Oenothera.—The important deductions made by DEVRIES, from the results of a twenty-years' study of *Oenothera Lamarckiana* and its derivatives, have created an unusual interest in this species and its relatives. Numerous investigations have been made by many students, without any apparent exhaustion of the wealth of interesting phenomena presented. The oenotheras seem destined to yield results of great value for a long time to come, for the interest in the group grows greater rather than less with further study. The validity of some of DEVRIES'S conclusions rests upon the correctness of the assumption that *O. Lamarckiana* is a native species. Many diligent searches have been made in the effort to discover it in a natural habitat in America, but so far without success.

DAVIS[6] believes that *O. Lamarckiana* does not occur as a native species, but that it is a hybrid, probably between forms of *O. grandiflora* and *O. biennis*, and that it originated in European gardens, or that it may have occurred as a wild hybrid. To test this hypothesis he is making numerous crosses between different forms of these two species, and selecting those types among the hybrid progenies which most closely resemble *O. Lamarckiana*. He reports that all of the hybrid forms thus far produced by him differ from *O. Lamarckiana* in several important points, but that the resemblances of some of them to that species are such that the taxonomist would at least place these hybrids next to *O. Lamarckiana*. DAVIS is not convinced, by the evidence at hand, that the plants figured in certain old plates or described in various horticultural magazines of a century or more ago are to be safely referred to *O. Lamarckiana*, as they have been by several writers. The effort to synthesize *O. Lamarckiana* is being continued by the use of other biotypes of the two chosen species, and it is expected that some of these will offer a still closer approach to the desired result. Reports on these further studies will be awaited with the greatest interest, and especially regarding the capacity of any of the new forms to yield a series of true-breeding segregates, such as the forms derived from *O. Lamarckiana* which are now generally recognized as mutants.

All students of genetics who have handled the oenotheras in hybridization experiments appreciate the fact that they are quite anomalous in their hereditary behavior, and that they do not clearly follow the simple procedure usually observed in the hybrids of other plants and of animals. Under the circumstances, no far-reaching generalizations should be drawn from studies in the oenotheras except on the basis of extensive cultures and the most careful analysis of results. GATES[7] has made some features of *O. rubrinervis* and of a derivative from it, which he calls *O. rubricalyx*, the basis of generalizations regarding the nature of unit-characters, which appear to the reviewer not to observe this desired caution. *O. rubricalyx* differs from *O. rubrinervis* not only in amount of anthocyan in leaves and buds, but also to some extent in its distribution, the latter form having a red hypanthium, red midribs of the sepals, and red on the ventral surface of rosette-leaves and especially of their petioles, in which positions *O. rubrinervis* has a green or yellowish color. Nine cultures from self-fertilized *O. rubricalyx* gave in each case not only *O. rubricalyx*, but also *O. rubrinervis* offspring, though the ratios were not satisfactorily determined. The conclusion is reached that therefore *O. rubricalyx* is incapable of breeding true. The number of families is too small, however, to warrant this conclusion, for Mendelian expectation would allow six of the nine

[6] DAVIS, B. M., Genetic studies on *Oenothera*. II. Some hybrids of *Oenothera biennis* and *O. grandiflora* that resemble *O. Lamarckiana*. Amer. Nat. **45**:193–233. *figs. 18.* 1911.

[7] GATES, R. R., Studies on the variability and heritability of pigmentation in *Oenothera*. Zeit. f. Ind. Abstam. Vererb. **4**:337–372. *pl. 1. figs. 5.* 1911.

parents to be heterozygous, and it puts no strain on the "errors of random sampling" to account for the remaining three as a purely chance result. Reciprocal crosses between *O. rubricalyx* and *O. Lamarckiana* seem to have resulted in each case in a progeny of *rubricalyx* and *Lamarckiana*, though the determinations were defective. The appearance of these two types in the first generation seems at first glance to be distinctly unlike Mendelian behavior, but if the *rubricalyx* plants used for the crosses were heterozygous, two types should have been expected in the progeny. The author uses the expression "alternative inheritance" for cases in which the two parental types appear in the F_1 and breed true in later generations. This new use of the expression "alternative inheritance" will result in confusion if it is adopted by others, since all Mendelian inheritance is "alternative," as the expression is now generally used among geneticists.

GATES is of the opinion that *O. rubricalyx* represents a progressive mutation from *O. rubrinervis*, and that it is not to be explained on the basis of the presence and absence hypothesis. For the simple and direct, though somewhat formal and figurative, terminology generally used in describing Mendelian behavior, GATES would substitute " a quantitative readjustment of the relation between the substances which by their chemical interactions produce anthocyan, and those which decompose it as soon as formed, or which, by their presence, divert the metabolic processes and bring about chemical reactions of a different sort."

While the extent of the anthocyan in *O. rubricalyx* proved to be strictly inherited, the various grades of color in *O. rubrinervis*, whose wide range of pigmentation is described and figured in detail, were proved on extensive cultures not to be inherited, the offspring from plants having a relatively low degree of pigmentation having the same average pigmentation as the offspring from parents having a high degree of pigmentation. A strain of oenotheras received from Liverpool, England, which obviously constituted a somewhat heterogeneous population, showed an amount and arrangement of color on the buds similar to those of *O. rubrinervis*, but in this strain the degree of pigmentation was partially hereditary. It seems probable that the apparent inheritance of the degree of pigmentation in the latter case is due to the heterogeneity of the strain, and that the different progenies which resembled their parents in the degree of pigmentation of their buds represent the segregation of more or less pure genotypes from the hybrid mixture.

DEVRIES[8] has continued his studies on hybridization in the oenotheras, and announces results of unusual theoretical interest, which together with the discovery of "twin hybrids," earlier reported[9] by the same author, the reviewer

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[8] DEVRIES, H., Ueber doppeltreziproke Bastarde von *Oenothera biennis* L. und *O. muricata* L. Biol. Centralbl. 31:97–104. 1911.

[9] ———, On twin hybrids. BOT. GAZETTE 44:401–407. 1907.

believes will go far toward solving the anomalous hereditary behavior of the oenotheras. As reported in *Die Mutationstheorie* (2:471), reciprocal hybrids among the oenotheras are frequently unlike, being usually similar to the type of the pollen parent. To discover the significance of this phenomenon the author crossed together the reciprocal hybrids, thus $(A\times B)F_1\times(B\times A)F_1$. The results of such a cross he calls "double reciprocal hybrids." For the study of these double reciprocal hybrids he has used chiefly *O. biennis* and *O. muricata*. It will be seen that there are two possible combinations of the same reciprocal hybrids, e.g. (*biennis*×*muricata*)×(*muricata*×*biennis*) and (*muricata*×*biennis*)×(*biennis*×*muricata*). In the first case the *muricata* occupies the middle place in the formula and *biennis* the extremes, while in the second case the position of the two parent species is reversed. The remarkable and unexpected result of these crosses is the complete disappearance of the characters of the species occupying the middle position in these formulae. Thus (*biennis*×*muricata*)×(*muricata*×*biennis*) produces a progeny consisting only of *biennis*, while the alternative arrangement of the parents results in a progeny of pure *O. muricata*, the *biennis* having completely disappeared. This remarkable result does not belong only to the *biennis-muricata* cross, but six other combinations in which *O. biennis* entered as one of the parental types followed always the same law. These six combinations involved a small-flowering "*O. biennis*" from Chicago, *cruciata*, *strigosa*, *Hookeri*, *Lamarckiana laeta*, and *Lamarckiana velutina*. The same principle holds when one of these F_1 hybrids is crossed with one of the parental types, e.g. $(A\times B)F_1\times A$, the result being the same as if the middle parent had not entered into the breeding (in the example the offspring are all pure A). The progeny of such a cross the author calls "sesquireciprocal hybrids."

From these results it is obvious that the eggs and sperms carry different morphological potentialities. The cross A×B results in an AB heterozygote which produces A eggs and B sperms. The reciprocal cross produces only B eggs and A sperms. DeVries offers the explanation that both A and B eggs and A and B sperms are produced, but that the B eggs and A sperms fail, an assumption which is in accord with the observation that about half the ovules and half the pollen grains are abortive.

DeVries has gone further and discovered just what potentialities are carried by each sex. In both pure-bred *O. biennis* and in its crosses with *O. muricata*, the pollen-borne type is epistatic to the seed-borne type, so that the latter is never seen; but in a series of crosses of *O. biennis* with "*biennis* Chicago," *cruciata*, *Hookeri*, *strigosa*, and *Lamarckiana*, the seed-borne type of *O. biennis* is epistatic to the pollen-borne type of the other species, thus allowing it to become visible. The F_1 offspring between *biennis* ♂ and all these other species resemble *O. biennis*, which therefore represents the pollen-borne type. The F_1 between *biennis* ♀ and all of the species mentioned gives a new form unlike *biennis* and unlike any of the pollen parents, but essentially identical in all the crosses. This new form is the seed-borne type of *O. biennis*.

The author calls it the "*conica*-type," because of its characteristic thick conical buds. It has been described already as "*velutina*" in the same author's papers on "twin hybrids." While *O. muricata* was incapable of such complete analysis as was given to *biennis*, owing to the fact that many of its hybrids are weak or sterile, several crosses in which *muricata* was used as the seed parent show that in this species also there is a morphological type determined by the egg cell different from that carried by the pollen cell. The seed-borne type of *O. muricata* is called by DEVRIES the "*frigida*-type." It comes to light in crosses of *O. muricata* as seed-parent with "*biennis* Chicago," *Hookeri*, and *strigosa* pollen parents. It has tall, strong, nearly glabrous stems, but little branched, with flowers resembling *O. biennis*.

These results are of unusual theoretical importance, and the study of double reciprocal hybrids will no doubt lead to the discovery of other instances in which different potentialities are borne by eggs and sperms.

HONING[10] has made a statistical study of the "twin hybrids" of *O. Lamarckiana* and *O. rubrinervis* in the attempt to identify the *velutina* with *rubrinervis* and *laeta* with *Lamarckiana*. He finds in nearly all the morphological characteristics which differentiate the twin hybrids a fairly close parallel with the characters of the mentioned species, and concludes that while they are not identical, *laeta* has a strong predominance of *Lamarckiana* characters, and *velutina* a similarly strong predominance of *rubrinervis* characters. He is convinced by these facts that *O. Lamarckiana* and *O. rubrinervis* are both of hybrid nature, each possessing in the latent state the characters of the other. He offers no suggestion, however, as to how it happens that this hybrid nature fails to express itself when *O. Lamarckiana* and *O. rubrinervis* are self-fertilized.

ZEIJLSTRA[11] has discovered that the most common form of *O. nanella* is parasitized by a *Micrococcus* which forms zoogloea-like masses in the cavities of the cells. The diseased plants have a characteristic appearance which makes them easily detected even in their early stages. Normal (that is, undiseased) *O. nanella* has also been discovered, but much more rarely, and the latter has never fruited. It is suggested that the true normal *O. nanella* may have been frequently overlooked, owing to its resemblance to *O. Lamarckiana*. How it happens that all the offspring of the diseased *O. nanella* are of the parental type needs investigation. The author points out two alternative explanations: namely, that this diseased strain of *O. nanella* inherits a susceptibility to the attack of the *Micrococcus*, or that the germ cells are themselves infected by the parasite. In the latter case a microscopic study of the germ cells should perhaps detect the presence of the *Micrococcus*.—GEO. H. SHULL.

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[10] HONING, J. A., Die Doppelnatur der *Oenothera Lamarckiana*. Zeit. f. Ind. Abstam. Vererb. **4**: 227–278. *figs. 10.* 1911.

[11] ZEIJLSTRA, H. H., *Oenothera nanella* DeVries, eine krankhafte Pflanzenart. Biol. Centralbl. **31**: 129–138. *figs. 5.* 1911.

The determination of sex.—In a recent paper on the determination of sex, STRASBURGER[12] adds to his already extensive contributions to this difficult subject. As in previous papers, he maintains that the problem is phylogenetic, and that there is a striking parallelism between the animal and plant kingdoms in the evolution of sex. In both kingdoms the original differentiation appears only in the haploid generation, but with the differentiation of sex in this generation came fertilization and the formation of a diploid generation, which, in both animals and plants, became the dominant one.

The point at which the separation of sexes takes place in various plant groups is noted briefly; the statements, in most cases, depending upon facts already known, rather than upon cytological or other evidence in connection with this particular paper.

In monoecious Chlorophyceae the thallus is bisexual and the sexes are separated at the formation of oogonia and antheridia; at fertilization the two sexes are united; the reduction of chromosomes takes place during the first two divisions of the zygote, but is not accompanied by any separation of sexes, the product of the zygote being bisexual. In dioecious Chlorophyceae the separation of sexes occurs at the reduction division, so that the products of the zygote are unisexual. Thus the separation of sex tendencies appeared first in connection with the reduction divisions.

In monoecious bryophytes there is no separation of sexes at the reduction divisions, the separation occurring later, at the formation of antheridia and archegonia; but in dioecious forms the separation occurs at the reduction division. That the separation of sex tendencies as well as their union at fertilization is decisive, is shown by the fact that protonema from vegetative cells of a sporophyte of a dioecious moss produces leafy plants bearing both antheridia and archegonia.

In homosporous pteridophytes there is no separation of sexes at the reduction divisions, the spores being bisexual and the sex tendencies being separated later in the gametophytes arising from the spores. The division which many homosporous pteridophytes show in their gametophytes is due merely to external factors, the gametophytes being really monoecious. In heterosporous forms the separation of sexes does not occur at the reduction divisions, but much earlier, during the divisions leading to the formation of spore mother cells, so that the spore mother cells are already all male or all female, all the spores of a microsporangium producing male prothallia and all those of a megasporangium producing female prothallia. The two sex tendencies are united in the sporophyte, which can then produce both microsporangia and megasporangia. Through the heterospory of the sporophyte the dioecism of the gametophyte became firmly established.

In seed plants the sexes are recognized by the external "sex organs" of

[12] STRASBURGER, EDUARD, Ueber geschlechtbestimmende Ursachen. Jahrb. Wiss. Bot. **48**:427–520. *pls. 9, 10.* 1910.

the diploid sporophyte. In heterosporous plants there is no sex differentiation except that which leads to the formation of microspores and megaspores, for from a microspore mother cell come four spores which produce only male products, and from a megaspore mother cell come four spores which produce only female products. If all sporophytes were bisexual, the problem would be comparatively simple, but there are sporophytes which produce only microsporangia or only megasporangia, and these dioecious seed plants, although their number is comparatively small, have been used extensively in the study of sex problems.

A large amount of experimental work is recorded, the principal forms used being *Mercurialis annua*, *Melandrium rubrum*, and *Elodea canadensis*.

In *Mercurialis annua* ovulate plants sometimes bear occasional staminate flowers, and similarly, staminate plants sometimes bear occasional ovulate flowers. STRASBURGER had already found that the flowers of an ovulate plant, when pollinated from a staminate flower on the same plant, bore seeds which produced only ovulate plants. He now finds that the scattered ovulate flowers on a staminate plant, when pollinated from the same plant, bear seeds which produce only staminate plants. Some plants have ovulate flowers with staminate flowers growing up through them in a sort of proliferation. Pollination of such ovulate flowers with pollen of the proliferating flowers gives rise to seeds which produce both ovulate and staminate plants. The conclusion is that in the scattered staminate flowers the male tendency has become weakened, and that in the scattered ovulate flowers, the female tendency has become weakened.

In the dioecious *Melandrium rubrum*, pollination was effected by pollinating with thin transverse sections of still unopened anthers. It was hoped that in this way pollination would be effected with about equal numbers of pollen grains with the stronger and with the weaker male tendencies. In all, 1475 seeds were secured, and from these there were obtained 1124 seedlings, 1035 of which reached the flowering stage. Of these 376 were staminate and 659 ovulate, the ovulate being strongly dominant.

The work on *Elodea canadensis* is interesting, but is still in an unfinished condition. Although ovulate plants have long been abundant in Europe, staminate plants are not available. Staminate plants and seeds were secured from Wolf Lake, near Chicago, and hundreds of stigmas were pollinated, each with a single pollen tetrad. Fertilization has taken place, but seeds are not yet ripe. If each ovary should produce four seeds, two of which should produce staminate plants and two ovulate plants, there would be some definite data.

The general conclusion from the data, only a small part of which has been indicated here, is that all eggs are female and all pollen male, but that some pollen has a strong and some a weak male tendency. Pollen with a strong male tendency overcomes the female tendency of the egg, while pollen with the weak male tendency is overcome by the stronger female tendency of the egg. The

fact that eggs of apogamous forms may produce staminate as well as ovulate plants does not affect the problem, since such eggs are diploid, and the sex tendencies have not yet been separated. The case is similar to that of budding.

A cytological study was made in *Melandrium rubrum*, *Cannabis sativa*, and *Mercurialis annua*, but at present no cytological features have been recognized which seem to have any bearing upon the problem of the separation of the sexes. In *Melandrium rubrum* one chromosome is constantly larger than the others, as was noted during the reduction divisions and in vegetative cells, but it could not be connected with sex differentiation.

The problem is unusually large and difficult, and the present paper suggests many points of attack.—CHARLES J. CHAMBERLAIN.

Crown gall.—The most noteworthy contribution recently made to plant pathology is the bulletin on crown gall of plants by SMITH, BROWN, and TOWNSEND.[13] This disease, on account of its wide distribution and the conspicuous nature of the deformations to which it owes its name, has long attracted the attention both of practical horticulturists and plant pathologists. Yet, with the exception of the work of some Italian investigators, little has been done to work out the etiology of the disease. From general observations it has been believed that the disease is communicable, and one investigator (CAVARA) isolated an organism from a gall of the European grape and established a strong probability that it was the causal organism of that particular gall. The nature of the outgrowths known as crown gall and occurring on a great many different kinds of plants, the cause of their occurrence, and the relation of the crown galls of different plants to each other, have remained among the most obscure problems in the whole field of plant pathology. The results of investigations on these problems are reported in the present bulletin.

The work begins with a short historical sketch of the more important investigations on the crown gall, special emphasis being laid on the work of Italian investigators who first ascribed the disease to bacteria. This is followed by an account of the isolation of the causal organism, and the evidence showing that the crown gall of various plants is due to bacterial organisms; and that these belong either to a single species or to closely related species or strains, each of which can be inoculated into many species of plants. The morphology and cultural characteristics of the organism (*Bacterium tumefaciens* Smith and Townsend) are described at length. Further, the similarity between crown gall and some animal tumors is discussed. This similarity is emphasized by the occurrence of metastases in infected plants. The last part of the bulletin relates to the practical aspects of the subject, together with a statement of the plants infected and their distribution. The evidence given in the first part is supported by 36 excellent plates.

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[13] SMITH, E. F., BROWN, NELLIE A., TOWNSEND, C. O., Crown gall of plants; its cause and remedy. Bur. Pl. Ind. Bull. **213**: pp. 200. *pls. 36. figs. 3.* 1911.

It may be said that the beginning of the present work dates back to the discovery of gall-like outgrowths on the stems of the Paris daisy (*Chrysanthemum frutescens*) in 1904. It was not until 1906, after many unsuccessful trials, that an organism was isolated which when inoculated into sound plants caused the growth of galls similar to the ones from which the organism had been obtained. The organism was inoculated from pure cultures into many different plants, several hundred inoculations having been made. The results showed that on nearly all herbaceous plants tried, such as daisy, pyrethrum, tobacco, clover, cotton, sugar beet, hop, and others, galls were produced as a result of the inoculations. Inoculations into such woody plants as rose, grape, almond, poplar, and Persian walnut also gave galls, but with less frequency than the herbaceous plants. Inoculations on a number of other plants did not result in the formation of galls, although in some instances inoculations had been successful in other experiments with the same plants. Later, crown gall organisms were isolated from a large number of other plants, both woody and herbaceous, including the common nursery trees, as apple, peach, and poplar, which suffer most seriously from the crown gall, and such organisms were also capable of infecting a number of hosts besides the original one. The "hairy root" of apple, which has been more or less associated with crown gall in the minds of nurserymen, was found to be due to the same organism which when inoculated into other plants, as the sugar beet, for instance, gave galls with the characteristic hairy roots. The vast amount of evidence of this nature presented in the bulletin shows that the crown gall and similar tumors, and the hairy root disease of various plants, are due to bacteria, and that the organism of each kind of plant is capable of being inoculated at least into several other plants. The organisms from different sources, while similar in their general characteristics, show minor cultural differences. This behavior leads the authors to leave undecided the question whether the organisms constitute several species or a single species with several races.

An interesting comparison is made between the crown gall outgrowths and animal tumors to which they show resemblance in growth and organization. This resemblance is carried still farther by the formation by the plant galls of metastases, which occur at some distance from the primary gall, but without the intervention of new infections. It is suggested that the metastases occur as a result of growths from the primary galls.

Another important idea is brought out in a number of experiments which tend to show that plants acquire immunity to the crown gall organism as a result of repeated inoculation. If the result of those experiments should be confirmed by future work, this would be the first instance of immunity in plants analogous to that in animals.

This work has removed from the domain of speculation the cause of crown gall and kindred diseases affecting many plants. These diseases, in all their varied manifestations, are shown to be due to a common cause. The enormous

amount of evidence presented leaves no doubt as to the correctness of the conclusions. Aside from having solved one of the most obscure problems of plant pathology, the authors have shown that it has a more general bearing in showing that these plant galls, due to bacteria, present many analogies to animal tumors. The successful isolation of causal bacteria from the plant tumors, after many failures, leads one to hope that the work will stimulate renewed search for organisms in animal tumors.—H. HASSELBRING.

Coastal floras.—H. CHERMEZON[14] has recently made a contribution to the study of coastal floras. In the introduction he calls attention to the well known peculiarity of these floras, the interest they have excited in botanists since ancient times, and the theories advanced as to the relation between them and salt in the soil.

The main part of the work is divided into three sections. In part 1 is given a description of the structure of the leaf and stem of a large number of plants of the coast, chiefly of France, but also of some of the salt-desert regions of Tunis. In part 2 a study is made of the characters peculiar to plants of the coast. There are three categories of habitat: (1) the region of sands, including (*a*) beaches and (*b*) dunes; (2) region of rocks and cliffs, including (*a*) rocks and bowlders exposed to the spray and (*b*) the top of cliffs; (3) damp salty places including (*a*) muddy flats and salt marshes (the halophytic zone par excellence), and (*b*) damp prairies, not reached by the sea, which form a transition to the flora of the interior.

Part 3 is devoted to a discussion of the flora. It is divided into two parts: (1) marshes, rocks, and beaches; and (2) dunes and sands. The transition between the two is made by the plants of the beaches which have characters common to both. In the first group succulency and development of water-tissues are the striking features, while the second shows more often thickening of the cuticle, sinking of stomata, and abundance of hairs. As the stations of the first group are the most salty, while the dunes are not salty at all, the author distinguishes two sorts of floras, the halophilous and the xerophilous. The xerophilous flora reaches its maximum in the dunes, where the characters are such as are met with in other xerophilous floras; but it is less specialized than that of the desert or even the Mediterranean flora, since the dryness is less pronounced and less continuous. The halophilous flora occupies the beaches, the rocks and bowlders, and the salt marshes. The beach and the dunes are not distinct, plants passing from one to the other; but a great many sand-loving plants of the dunes are absent from the beach, which the author explains by the presence of salt, small in amount but sufficient to eliminate them. The rocks and bowlders in the vicinity of the sea, exposed to the spray, are occupied by a flora with special characters, less halophilous than those of

[14] CHERMEZON, H., Recherches anatomiques sur les plantes littorales. Ann. Sci. Nat. Bot. **12**:117–313. *figs. 52.* 1910.

the beach flora. In the salt marshes is found the most halophytic flora. Several plants have hygrophilous characters, as canals or lacunae.

In conclusion, the coastal flora is composed of xerophilous and halophilous members, showing points of contact; plants of the xerophilous flora have moderately xerophilous characters, such as epidermal protections slightly developed; plants of the halophilous flora exhibit succulency of leaves and of stem and water-tissues; characters in common to the two are isolaterality of leaves and compact structure of the mesophyll.

The author objects to SCHIMPER'S placing halophytes among xerophytes and says: "The assimilation results from confusion between the two different parts of the coastal flora; truly halophilous plants do not often show xerophilous characters; such characters at least in the marshes would be very difficult to explain in spite of the arguments of SCHIMPER; besides, several species of the salt marshes on the contrary have certain hygrophilous peculiarities. The fact that there are succulent plants outside the coast simply proves that succulency may be related to other factors of the soil besides salt, but its frequency in plants of salty earths shows that there exists a certain relation between succulency and salt. The nature of the relation is impossible of determination." Either argument, that succulency permits plants to resist the toxic action of salt, or that the appearance of succulent plants on the coast is due to lack of competition there, he thinks insufficient, and concludes that a flora as special as that of the salt marsh should be considered as halophilous in the proper sense of the word. The author admits that succulency may be due to other factors than salt in the soil, but does not make it clear why he objects to considering that "physiologically dry" soil and really dry soil may occasion the same structure. SCHIMPER'S argument seems to us to stand. —A. M. STARR.

Inheritance of flower-form and color in Digitalis.—A familiar garden variety of *Digitalis* has the central axis terminated by a peloric flower. KEEBLE, PELLEW, and JONES[15] find that this form is a Mendelian recessive to the typical form, and that, as might be expected, the inheritance is the same whether the seeds are taken from the peloric flower or the normal zygomorphic flowers of the same plant. The flower-color is referred to three pairs of allelomorphs: *Mm*, a magenta factor; *Dd*, a darkener which changes the magenta to purple; and *Ww*, a dominant white factor which removes the effect of *M* except in the small spots which occur on the corollas of all *Digitalis*. When *M* is present these spots are red, and when absent they are yellow.

MISS SAUNDERS[16] has studied the inheritance of an interesting form of

[15] KEEBLE, F., PELLEW, MISS C., and JONES, W. N., The inheritance of peloria and flower-color in foxglove (*Digitalis purpurea*). New Phytologist **9**:68–77. *fig. 1.* 1910.

[16] SAUNDERS, MISS E. R., On inheritance of a mutation in the common foxglove (*Digitalis purpurea*). New Phytologist **10**:47–63. *pl. 1. figs. 12.* 1911.

Digitalis which has been noted occasionally for nearly a century, and which was described by CHAMISSO in 1826 under the name *D. purpurea heptandra*. The characteristic features of this form consist of a dialysis of the corolla and staminody of three or more of the petals, thus producing flowers having most typically 7–9 stamens, and scarcely to be recognized as a *Digitalis* flower at all. The degree of development of these characters is variable, and somewhat influenced by the environment, but there is no real transition to the normal form. This form proves to be like the peloric variety, a Mendelian recessive to the normal. The reviewer has also been studying the inheritance of this peculiar variety for five years, and has reached the same conclusion. Miss SAUNDERS confirms the results of KEEBLE, PELLEW, and JONES as to the color-characters.—GEO. H. SHULL.

Water relations of desert plants.—FITTING[17] has studied the water relations of the plants growing on the Sahara. He finds, as LIVINGSTON found for the Arizona desert, that the water is generally gained from the surface layers of the soil and not by deep rooting. Many of the plants, especially the perennial shrubs not provided with water-storage organs, develop remarkably high osmotic pressure, which enables them to withdraw water from the comparatively dry soil. On the other hand, the annuals showed much lower osmotic pressure, with lack of ability to thrive in the most exposed places. In many cases the high pressures were due largely to stored NaCl, but frequently entirely to other solutes. Of the 46 species studied, 21 per cent showed an osmotic pressure exceeding 100 atmospheres; 35 per cent exceeded 53 atmospheres; 52 per cent, 37 atmospheres; while only 11 per cent showed osmotic pressures as low as 11 to 22 atmospheres. Species showing extremely high pressures in dry desert conditions show much lower pressures in moist situations. This marked power of certain plants to adjust their osmotic pressures to the water-withholding power of the medium in which they grow has been demonstrated for salt marsh plants by HILL,[18] a piece of work which FITTING does not cite. We have known little about the osmotic pressure of desert forms, and this work supplies much of the deficiency and makes this character of great significance in the physiology of these forms.—WILLIAM CROCKER.

Permeability.—SCHROEDER[19] has studied the semipermeable membrane of the wheat grain, and confirms the work of BROWN on the barley, but adds little that is new. The portion of the coat forming the semipermeable mem-

[17] FITTING, HANS, Die Wasserversorgung und die osmotischen Druckverhältnisse der Wüstenpflanzen. Zeitsch. Bot. **3**: 209–275. 1911.

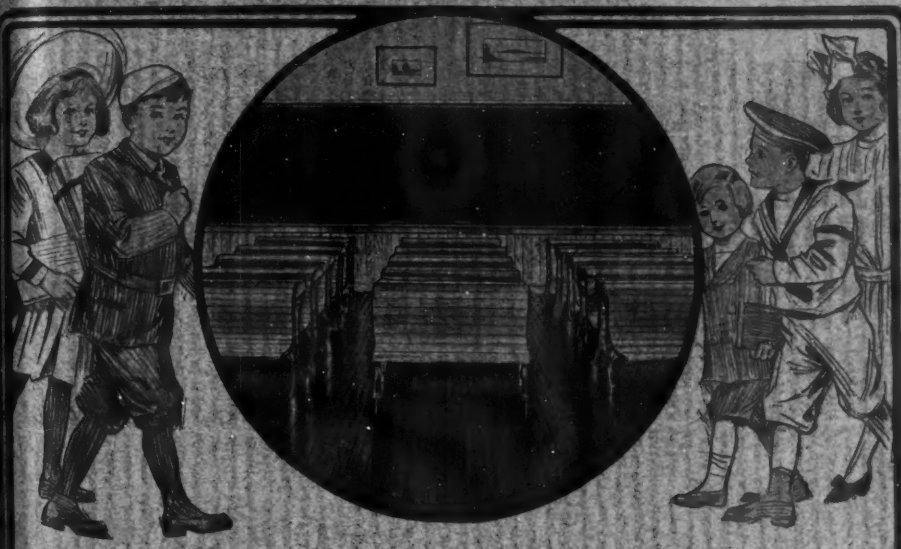
[18] HILL, F. G., New Phytologist **7**: 133–142. 1908; Rev. in BOT. GAZETTE **47**: 170. 1909.

[19] SCHROEDER, H., Ueber die selektiv permeable Hülle des Weizenkornes. Flora **102**: 186–208. 1911.

brane originates either from the inner integument or from the nucellus. The following substances dissolved in water cannot pass through the membrane: NaF, KCl, KNO_3, K_2CO_3, Na_2CO_3, $BaCl_2$, Na_2SO_4, $MgSO_4$, $AgNO_3$, $COCl_2$, and sucrose; while $HgCl_2$, iodine, methyl and ethyl alcohols, ethyl ether, acetone, acetonitril, and chloroform with water as a solvent will enter. In dead grains the membrane still retains its semipermeable character. It is shown that water and the solutes capable of entering do so mainly through the embryo end of the grain. The membrane becomes permeable to $AgNO_3$ if alcohol is added to its water solution. Ether renders the coat more readily permeable to water, while treatment with osmic acid renders it less so. While this membrane, being of the non-protoplasmic type, is of great theoretical interest, it has not been demonstrated of any biological significance to the seed itself. In these cultivated forms it is probable that, if such a significance existed, it has been eliminated by selection. A study of this membrane in wild grasses might prove of interest. Many of the wild forms show delayed germination, and in one at least, wild oats, rupturing the coat overcomes the delay.—WILLIAM CROCKER.

Leaf-fall.—The phenomena accompanying the process of defoliation have been investigated by LEE[20] in nearly 50 species of trees and woody plants. The separation layer is formed from existing cells, with or without division, and cuts off the leaf by the degeneration and disappearance of the middle lamellae of the cells involved. The vascular elements are ruptured, but usually only after tyloses have filled them. The character of the invariably present protective layer is made the basis of classification, and the species studied are segregated according to whether the ligno-suberized protective cells arise (1) without further modification from existing cells; (2) after irregular division of existing cells; or (3) from a regularly active cambium. Whether the lignosuberization comes before or after defoliation leads to subdivisions of the first two classes. The production of a cork layer continuous with the periderm of the stem usually follows in the growing season succeeding defoliation.—GEO. D. FULLER.

[20] LEE, E., The morphology of leaf-fall. Annals of Botany **25**:51–106. 1911.



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